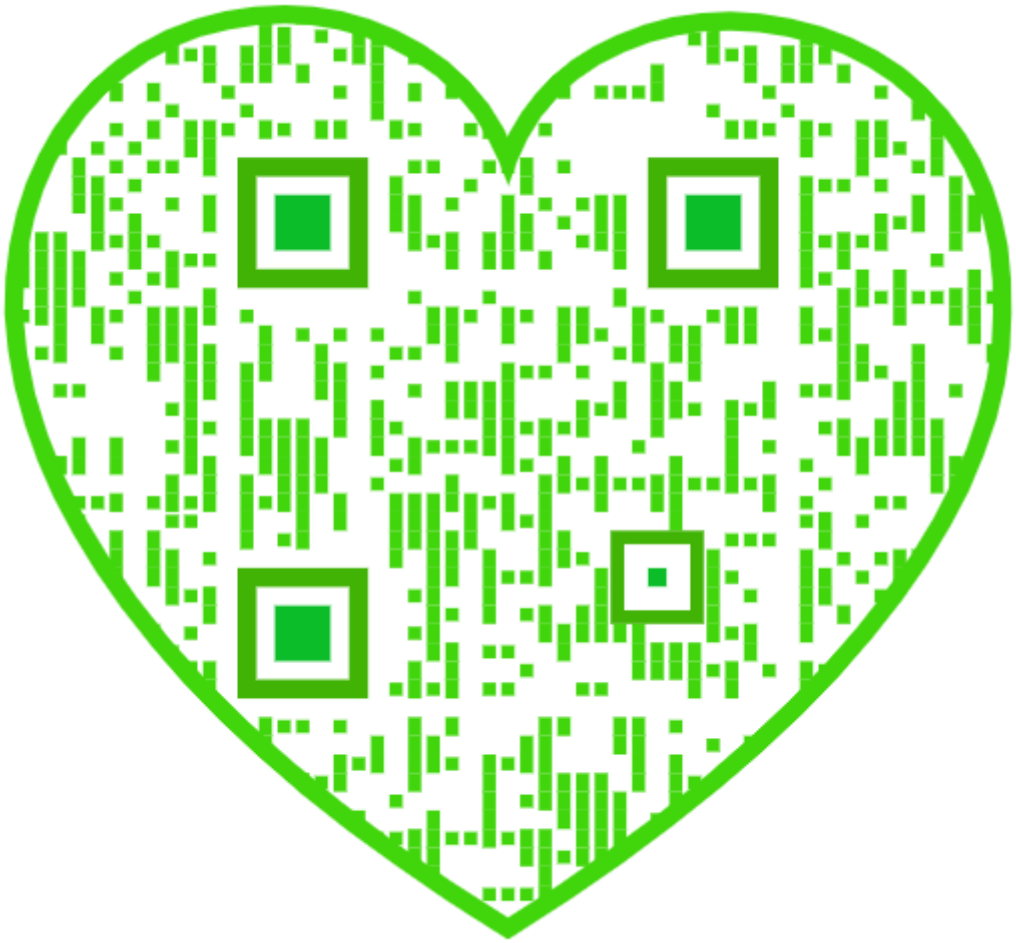

THE

POTATO DISEASE

AND

HOW TO PREVENT IT

BY

FREDERICK BRAVENDER

AUTHOR OF 'HOW TO PREVENT FAMINES IN INDIA' ETC.

W. G. FARLOW.

LONDON:

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With the Author's Compts

PREFACE.

I SHOULD have preferred to delay the publication of my notes on the Potato Disease for another year, until additional information could have been obtained on one or two points; but the losses by the disease last year were so very great, and the attention of the public so generally drawn to it, that on consideration I decided to publish without delay such information as I possessed; and if this little work should meet with a favourable reception on the part of the public, any additional information might be readily embodied in future editions.

THE AUTHOR.

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THE POTATO DISEASE

AND

HOW TO PREVENT IT.

CHAPTER I.

NOTWITHSTANDING all that has been written on the subject of the potato disease, it appears to me that there is an opening for a work treating of it from a practical point of view, and embodying at the same time our most recent scientific knowledge. There are a great many facts with regard to the disease which I have never seen brought before the public; and, in the case of other facts which have been brought forward, an entirely wrong interpretation has in some instances been put on them. I also find that a great amount of ignorance prevails generally with regard to the disease; not only amongst gardeners and labourers, but also to a certain extent in the case of others whose education and experience would lead one to expect differently.

The potato is certainly not cultivated at present in the way it ought to be, nor has any effort been made to meet the attacks of the disease upon well defined principles. I hope the remarks contained in the following chapters will be the means of introducing a better order of things.

Some years ago very great interest was taken in the potato disease generally. Its sudden appearance, and the apparent mystery which attended its arrival, the large loss of life, and the important economic results that it produced in Ireland, all tended to increase the interest in the subject;

and almost anything written, however crude, was published with welcome, and conclusions drawn as to its nature and origin before sufficient data had been obtained to enable one to arrive at anything like a satisfactory conclusion. In fact, the potato disease was in fashion. But now, when ample time has elapsed to enable one to procure sufficient data to arrive at an overwhelming conclusion as to the nature and origin of the disease, nearly all interest appears to have subsided; and, although our losses by the disease are nearly as great as ever, the potato is abandoned to its fate, and the disease allowed to do its worst. This is not a desirable state of things. Further efforts ought to be made to stop its ravages, and I have been trying some experiments lately with that object in view.

The first thing necessary, is to know what the cause of a disease is, and to get a good knowledge of all the symptoms and facts connected with it; then you are in a much better position to alleviate the symptoms if you do not effect a cure, and are able to direct your efforts just to those points where they are required.

First Appearance of the Disease.

The first thing to be ascertained, with regard to the disease, was as to the time when it first made its appearance. I have looked over a great many works on Potato Cultivation previously to 1845, but have not succeeded in finding any allusion to it.

In the article on the Cultivation of the Potato in the 'Book of British Husbandry,' published by the Society for the Diffusion of Useful Knowledge, in alluding to the diseases to which the potato was liable, it says that the principal disease affecting the potato is the curl, &c. Again the *Gardener's Chronicle and Agricultural Gazette* was the principal paper treating on horticultural and agricultural affairs in 1844; and, if anything unusual occurred in the agricultural world, you were pretty sure to see some notice of it. The bound volume for 1844, containing all the numbers for that year, is before me; but I have searched in vain for one single letter or intimation with regard to the potato disease. That alone is quite sufficient to establish the fact that it was not generally prevalent in that year, and one would be almost disposed to go further and say that it did not exist here, which many believe to have been the true state of the

case; but there was one writer who said he noticed it in Kent in 1844, and it is quite possible that it may have existed to a small extent there in that year. It must be remembered that the weather in 1844 was remarkably fine and dry, which no doubt tended to prevent the spread of the disease; but, supposing this to be the true state of the case, it only prevailed to a small extent, and therefore it will be more convenient to refer to it as the disease of 1845. Some writers thought the disease had been prevalent here for many years, and had been observed by them; but, on carefully reading their remarks, I agree with the Rev. M. J. Berkeley that they were in error, and that it was the dry rot of Martius, a previous fungoid disease, which they had mistaken for the new disease. Martius's account of this disease is copied in the Appendix.

The Disease in England.

The very first intimation that I have been able to find with regard to anything being amiss with the potato crop in England, is a communication from Dr. Bell Salter of Ryde, in the Isle of Wight, which appeared in the *Gardener's Chronicle* of August 16, 1845. The following is an extract from his letter:—

'Potato blight—a blight of unusual character, which almost universally affects the potatoes in this island—having been the last few days repeatedly brought to my notice by several gardeners, I am induced to lay before the readers of the *Chronicle* such observations as I have yet been able to make on the subject, being desirous to know whether this plague be in reality, as it is here generally supposed, an entirely new one; whether it be local or general in other parts of the kingdom; and principally, and lastly, what is the best course to pursue when it has made its appearance. The first appearance is a dark spot on the margin of the leaf, which withers the leaf and spreads rapidly to the stem. The discolouration soon spreads along the stem in the course of the vessels and the whole plant rapidly becomes black, so that within three days after a plant is attacked it has become totally destroyed. With this appearance in the upper part there coexists a fatal change in the tubers: they become likewise spotted at first near the eyes on the upper surface; the cuticle separates; the substance becomes friable; and the

change soon spreads throughout the whole potato. These are the leading facts of this destructive visitation, and I regret that I cannot add any remarks which throw light on the subject. I may, however, make one or two remarks or suggestions respecting the matter. All situations, whether high or low and whatever the nature of the soil, appear to be equally visited. So universal is the evil that the consequences are likely to be very serious, as in a long journey on horseback I have carefully watched every potato ground as I passed along, and not one could I see uninjured.'

The writer speaks of the blight being of an unusual character, and apparently new; and his description of the disease is so good as to enable us to identify it with certainty. This letter was soon followed by others, as the disease gradually spread over the country; and the correspondence became larger and larger, and that in the *Gardener's Chronicle* alone, before the end of the year, would be sufficient to fill a large volume, although in the previous year there was no mention of the disease whatever.

Dr. Salter's letter appeared in print on August 16; and it is probable he wrote it about a week before it was published; and, as the disease must have been going on for a little time before it became general, we may say that it began in the Isle of Wight about the middle of July. In the following week (August 23), Dr. Bell Salter sent another letter; and several other correspondents wrote, one from Jersey, speaking of the disease as general there, although not so bad as in the Isle of Wight, and that it had appeared three weeks before he wrote—say the end of July. Several other letters were written, from which it appeared that the disease had made a general attack on the south coast of England, early in August; and one writer from Plymouth spoke of hundreds of acres having been destroyed in Devon and Cornwall, where it must have begun somewhat earlier. At this early stage, writers began to start theories to account for the presence of the disease, of which the following extracts are specimens:—'We find the potato crop in the neighbourhood of Havant is also affected, but not to so great an extent as your columns describe the injury to have been in the Isle of Wight. On digging up the roots, the tubers nearest the surface of the ground are in general the only ones affected, though in some plants the injury ex-

tends throughout the potatoes belonging to that root; but where it does not so extend the rest of the tubers appear perfectly well grown and healthy. It certainly is not a disease of the root, but appears to be the consequence of an injury done to the haulm and leaf. Is not the cause to be attributed to the severe winds and white frosts experienced a short time ago injuring all above the ground, and preventing the vessels of the plant from drawing up the juices from the roots, and these tubers full of stagnated fluid immediately decay? Supposing this to be correct, I have practised the cutting off the haulm, with a reaping hook, about an inch below the earth, into where the frosts and winds might be supposed not to have injured the vessels of the plants, hoping, by these means, to induce them to bleed, and thereby relieve the tubers of their stagnated fluids, &c.' Another writer says:—'I believe those persons are perfectly correct who ascribe the potato disease to an excess of moisture to the plant, consequent on the late continued rain and absence of sunlight, and that it has been greatly aggravated by a too retentive soil. Our garden is so thoroughly drained that, in most summers, we suffer excessively from drought; and, though the haulm of the potatoes grown in it is more or less affected, the tubers themselves are comparatively uninjured; while in a piece of ground, apart from the garden, having a stiff clayey subsoil, the disease has been much more violent. I am inclined to connect the disease with the sudden heat of the end of June and beginning of July, as in a piece of Dutch potatoes which was not planted before that time scarcely a symptom of disease is perceptible.' These are fair specimens of the ideas of some of the earlier writers on the subject. I could put in a great many more, but they might not be interesting to the reader.

The disease from this period gradually extended northward, and about the middle of August was noticed in the counties of Gloucester, Wilts, and Oxford. The Rev. M. J. Berkeley wrote to the *Gardener's Chronicle* about this time, stating that the disease had not then appeared in Northamptonshire; but the following week he wrote to say that it had made its appearance. A little before this the disease had appeared in Cambridgeshire, Bedfordshire, Hertfordshire, and Buckinghamshire. About this time the disease appeared at Netherby, in Cumberland, in an isolated case,

whilst the potatoes in the surrounding fields were unaffected. I attribute this case not to the disease having spread to Cumberland all the way from the south coast; but believe, for reasons which will be afterwards given, that there was another centre of attack in the neighbourhood of Liverpool. By the end of September the disease, or 'murrain,' as it was called, had been observed in Yorkshire and other northern counties. The disease, in fact, gradually spread; and it will suffice to say that, although some parts of Wales appear to have escaped without much loss, and that in some of the northern counties it did not prevail so extensively, there does not appear to have been a single county in England that entirely escaped its ravages.

The Disease in Scotland.

The disease did not appear in Scotland so soon as in England. Until the end of September it did not seem to

Abstract of the State of the Potato Crop in Scotland, drawn up from the Returns to the Home Office, November 18, 1845.

Synods of	No. of Parishes in which disease has caused serious loss—*i.e.* ½ or above	No. of Parishes in which disease has caused inconsiderable loss—*i.e.* below ½	No. of Parishes in which disease has not appeared	No. of Parishes in which the crop is an average	No. of Parishes in which the crop is above an average	No. of Parishes in which the crop is under an average
Lothian and Tweeddale	49	24	...	30	26	21
Merse and Teviotdale	51	7	...	17	25	17
Dumfries	46	3	...	9	18	4
Galloway	29	3	...	9	18	4
Glasgow and Ayr	94	7	...	41	46	10
Argyle	21	7	8	11	22	3
Perth and Stirling	40	12	5	22	31	6
Fife	44	13	...	23	32	6
Angus and Mearns	8	32	26	29	17	19
Aberdeen	...	1	88	43	17	30
Moray	...	...	46	15	10	21
Ross	...	...	21	10	8	3
Sutherland and Caithness	...	...	22	6	16	...
Glenelg	1	2	16	7	4	9
Orkney	...	...	2	...	...	2
Shetland	...	...	...	...	...	...

have been much observed; but later in the season it became more prevalent, and from the reports in a return to the Home Office, November 18, 1845, the disease was reported as very bad in many places, and there were traces of it in almost every county. The Shetland Isles and Orkney appeared almost the only places which were exempt. The object of the return was to ascertain if the potatoes were sound in Scotland, so that tubers could be obtained from that country free from disease. The return was unfavourable, except as before mentioned; but, supposing it had been otherwise, the sound potatoes would not have been of much service when brought into contact with others; but this fact was not known then. (See table on opposite page.)

From this return it appears that the disease had caused a loss of a quarter of the crop or more in the Synods of Lothian and Tweeddale, Merse and Teviotdale, Dumfries, Galloway, Glasgow and Ayr, Argyle, Perth and Stirling, and Fife; and less than a quarter of the crop in Angus and Mearns, Glenelg, and Aberdeen; whilst in Moray, Ross, Sutherland and Caithness, Orkney, and Shetland it had not been then observed.

The Disease in Ireland.

On September 8 the disease was observed at Kinsale and Dublin. The *Gardener's Chronicle* said, on October 18, 1845:—'In Ireland matters seem to be worse. Although the statements which we found it our duty to make were lately declared to be exaggerations, and the existence of the murrain in Ireland was altogether denied, or asserted to be trifling and quite local, yet it now appears from the Irish papers to be raging in that country, and the most formidable consequences are anticipated.' The *Cork Examiner* was even of opinion that the Irish potato crop was then so much diseased that the Government was imperatively called on to throw open the ports without delay for the free admission of foreign corn.

Mr. Dillon Croker, in a letter to the *Constitution*, drew the following picture of the crop in the county of Cork:—'I came to Lord Kingstown's yesterday, and grieve to say I found all in this part of the country labouring under the delusion that the pestilence had not reached them, and that all the potatoes were sound; but, alas! in a drive of eleven Irish miles, I found every field more or less affected. I stopped on the road

wherever I saw a farmer digging potatoes. I asked if the crop were sound; immediately was I answered, "Perfectly so;" but, on going into the field, I had little difficulty in speedily convincing each that it was not so.'

The *Limerick Chronicle* said that in the county of Limerick the fields showed unequivocal symptoms of the rot.

The *Belfast Chronicle* said that the crop was as defective as report had represented, and that it could not be denied that the rot in that part was general.

The *Belfast Protestant Journal* said that the accounts from the towns round Belfast were discouraging, and that there was no doubt that in the counties of Down and Antrim the disease had spread to a serious extent.

By the end of the year the disease had spread over the greater part of Ireland, Galway and other parts on the west coast being the least affected. In October affairs assumed such a serious aspect, that Sir Robert Peel appointed Dr. Playfair and two other gentlemen as commissioners to go to Ireland and inquire into the subject. These gentlemen made every possible inquiry, and published altogether three reports on the disease. The first two touch on matters that are not of much interest to us now; but an extract from the last, which is the most important, is published in the Appendix.

The disease in Ireland assumed a much more serious aspect than in the other parts of the kingdom, on account of the fact of such a large number of people subsisting almost entirely on the potato. It was estimated that 4,500,000 persons lived on potatoes alone for eight months of the year, and that they consumed, on an average, 10 lbs. per diem; so that 45,000,000 lbs. per diem were required.

The average quantity of potatoes obtained from an acre of land in England used to be estimated at eight tons, or, allowing one ton for seed, at seven tons net. That being the case, the conclusion was arrived at that the potato crop of Ireland, for the mere consumption of those who fed upon it exclusively, amounted to the immense quantity of 10,800,000,000 lbs., and required for its production 688,647 English acres of land. But to this it was necessary to add the potato diet of 3,500,000 persons who only fed upon potatoes in part. If their consumption was taken at 1 lb. per head per diem for the whole year, and it was also assumed that during the four

months, previously excepted, 1 lb. per head per diem was also required for the rest of the population, already taken at 4,500,000, we should find the whole consumption of potatoes in Ireland to amount to 12,617,500,000 lbs. per annum, for producing which 804,687 English acres must have been under potato cultivation.

In ordinary tillage one ton of potatoes was required per acre for seed.* Therefore, merely to plant as much land as seemed necessary to feed the Irish population would have consumed above 800,000 tons, and required 100,000 acres of land in addition.

But as Ireland was an exporting country, sending her potatoes elsewhere in large quantities, it may not be too much to assume that the number of statute acres under cropping with this class was a million, or about one-fourteenth of the whole cultivated land.

Now, when the disease appeared in this country, although prevalent over a considerable part of it, it was not till the following year that its attacks were fully developed; and the results were disastrous, culminating in the Irish famine, with a loss of thousands of lives; and the English Government had to contribute 8,000,000*l.* for the support of the people. Besides this, the disease brought about sundry political changes. The growth of the potato was, in a measure, discontinued, and a large number of people emigrated to the United States of America; and, in a few years, the population was reduced by at the least three millions! Now, these important facts ought to be borne in mind, and have their due weight assigned to them, in considering the time when the disease first appeared in the country. It certainly does not seem at all probable that such tremendous consequences should have been suddenly produced in this country by a disease which had been prevalent for many years; neither do I think such was the case.

* A greater weight than is usually planted now.

CHAPTER II.

Theories which have been advanced to account for the Origin of the Disease.

THE potato is believed to have been introduced into the United Kingdom from Virginia by Sir Walter Raleigh, about the beginning of the seventeenth century, and was cultivated on his estate in Ireland and in other parts of that country in a small way for many years, and about 1694 was introduced into Lancashire, where its cultivation soon became general, and gradually spread over the other counties of England; and if we allow several more years from 1694 for this to have taken place, say until 1745, the potato must have been in general cultivation for at least a hundred years previously to 1845. For many generations the potato was thus cultivated year after year as before mentioned, and no sign of the disease exhibited; when, all on a sudden, it appeared, and spread rapidly over a wide range of country. What was the cause of the malady, and why did it not appear before 1845? This was the most important question of the day, which set everybody speculating as to its origin. From the very first appearance of the disease, and before scarcely any of the facts were known, every writer had a theory of his own. Several attributed it to the cold, wet season of 1845; others to the excess of electricity in the atmosphere, or the exhausted vitality of the tubers; and others to bad cultivation, frost, and even snails or worms. A German gentleman wrote a pamphlet attributing it to the absence of magnesia in the soil, and several pamphlets were written attributing it to the use of guano and other stimulating manures. Mr. Alfred Smee started the theory that the leaf of the potato was first punctured by an insect, a kind of aphis, and then the plant was attacked by the disease. He published a book on the subject dedicated to Prince Albert; and, I believe, retained that theory until the day of his death, which occurred not long since. I propose now to bring forward and review some of these theories; and if I were not afraid of tiring the patience of the reader, I would bring forward and review

every theory that has been advanced; but perhaps that is unnecessary, although at the same time I do not think I have left any out that are worth consideration.

Several writers have been disposed to attribute the origin of the disease to the electrical state of the atmosphere or an excess of electricity in the atmosphere, because they had observed the first appearance of the disease in potatoes soon after damp, sultry weather, particularly if followed by rain; and although this theory has been combated, and is not generally entertained, there are people who are still disposed to cling to it—amongst whom is the Rev. R. Fenn, the Rector of Woodstock, who has been very successful in raising new seedling potatoes. He sent a communication on this subject to the 'Horticultural Journal,' 1872, vol. ii.—an extract from which I think will be found interesting, and produce it here, although I cannot agree with his conclusions. Mr. Fenn says:—

I stand firmly by my old colours—an electrical state of the atmosphere in connection with rain being a chief and first cause in bringing about the potato disease. In the middle of July my new seedling potatoes induced me to go and stay for a few days in the neighbourhood of Bedfont, to watch their precocity and other particulars. Not a drop of rain had fallen on them for some weeks, and my supervisor was praying for some to come down. I did not sympathise with him, and my note-book ran thus:—'July 10: Atmosphere becoming very foul and thickening; I doubt the potato disease is coming sooner than usual this year.' In fact, I hinted at the advisability of getting them all up, as most of the sorts were already very nearly ripe; but we had named the day when friends and critics were to meet to admire or pass condemnation on them; so they were left to their fate and the elements, and I secretly hugged the hope that the already brewing tempests might pass over without rain, for then I knew my seedlings would remain without spot; or, otherwise, that the rain would come without the thunder and lightning, and then they would be equally safe. Well, on the 18th, the surcharged clouds could stand it no longer, and on the 19th storms passed over the neighbourhood. But I was forearmed for what I intended to do; so on that very evening, I worked till dark, taking up every other root of my choicest proved seedlings from the ridges, and so on for two or three days, both in storm and sunshine, till I had secured as many as I wanted of my precious ones. Many of them have since appeared in the Council Chamber at South Kensington; and it was lucky for me that my experience in the ways of atmospheric causes led me to make no delay, as those of their fellows, which I allowed to remain in the soil, with the hope of a

chance of being afterwards able to show them off in their growing state to my friends, &c., were almost destroyed by the disease, whilst not a single tuber is lost or touched by it of those which I lifted before they became scarcely blotched in the haulm.

Again, as regards my newest seedlings, which I raised from the seed apples, under glass last year, one-third of them I planted during the first quarter of last April, in the open garden, and one-third of them, from want of room, at Bedfont. In the beginning of July I began to have my suspicions about the disease, so I planted the remaining third part in any spare corner of the garden. Now, I beg of you to judge, by the result of these precautions, whether the disease is so profound a mystery as some people will have it to be. Of the April planted lot, which were all of them, as a matter of course, left to acquire their full growth and features, not two dozen tubers survived the murrain. Those sent to Bedfont were somewhat more lucky; but of those which I planted in July, the very smallest of the fry, anyhow and anywhere, and which began growing after the atmosphere had become cleared of its electricity, I finished lifting them in the third week of October, a most perfect lot, and surely they have been saturated enough and to spare with mere wet. So if merely plain rain, unaccompanied with tempest, will bring the disease, why is it that this last, and late planted third, was left scathless? [This will be answered.] I am most thankful to say that they were; and as the above will serve to show, by simply guarding myself against that state of the atmosphere, which is sure to arrive sooner or later during July and August, I have saved my credit and as many as I chose of my crops, plus the results of years of experimental crossings for the future.

I will now say a few words with regard to the electrical theory. All electrical phenomena, including thunderstorms, are subject to certain fixed laws, which never vary. All thunderstorms are produced by one of the following causes:—Either, first, by the passage of electrical fluid from one cloud to another; or, secondly, from the earth to the clouds; or, thirdly, from the clouds to the earth. This takes place, however, only under the following circumstances:—The cloud or part of the earth from which it passes must be in a positive state of electricity, and the cloud or part of the earth to which it does pass in a negative state of electricity; the exchange goes on until both are in the same condition. Another important law is that it moves by conduction—*i.e.* as some substances, such as metals, water, &c., are conductors, it will pass along them; but glass, fur, atmospheric air, &c.,

being non-conductors, almost totally obstruct its passage. As the first two causes of thunderstorms cannot influence vegetation, we will pass over them, and come to the third—the passage of the electric fluid from the clouds to the earth, which takes place in the following manner:—A cloud highly charged with positive electricity being surrounded by air, which is a bad conductor, cannot discharge its excess of electricity till it is in the vicinity of some good conductor, such as a church, house, or tree, or any other high object, to which it immediately passes (generally in a zigzag direction, owing to the resistance of the air), and is conducted to the earth, where it is distributed in a thousand different directions. Now, with these few simple, though well-established laws, what are we to make of the electrical theory? The only data I have seen advanced in support of it is, that it has frequently been noticed that the potato disease was first observed three days after a thunderstorm, if the weather continued wet or damp; but if the weather continued fine, no evil consequence ensued.

I will now reply to the question, 'If merely plain rain, unaccompanied with tempest, will bring the disease, why is it that this last and late planted third was left scathless?' The reason why they were not injured was, because all the potatoes in the immediate vicinity had previously perished from the disease—in fact, had been killed off—and there were none left to spread the infection to the seedlings. Seedlings are an entirely fresh start, and, if grown in uninfected soil, are not subject to the disease; and it is only on their being exposed to contagion that they are liable to it. Mr. Fenn has confounded the spread of the disease with the cause of it. Rain, with or without thunder, will not bring it, if not already present; but rain alone, with a certain amount of heat, will cause it to spread very rapidly; and in thundery weather, with a damp, close atmosphere, it spreads sometimes with amazing rapidity; but that is entirely a different thing from its being the origin of the disease. The disease was very bad in Gloucestershire in 1877, when there was a remarkable absence of thunderstorms, but a great deal of rain. Further, the fact mentioned by Mr. Fenn is only an isolated one among a number of others; and any theory, to be good for anything, must be capable of explaining all the facts; and the electrical

theory is not. Why was it the disease first appeared in Bermuda in potatoes, the seed tubers of which in every case had been obtained from the United States? and, why was it the disease never appeared at the Cape of Good Hope—one of the worst places in the world for thunderstorms—until some infected tubers were sent from England? And why did not the disease appear in England until 1845? This last question is the *bête noire* of the potato disease theorist. No matter how elaborate the argument, or how ingenious the theory, if you cannot answer that question in a satisfactory manner, all is labour in vain now the fungoid theory, as afterwards shown, is the only one capable of doing so. I am indebted for the next paragraph to Wilson's 'Encyclopædia.'

A peculiar atmospheric action, similar to what produces influenza in man, was supposed by Liebig and Klotzsch to have been the special cause; in fact, according to them, the potato had *caught a cold.* Liebig, in his work on the motions of the fluids in the animal body, after explaining the great importance of the cutaneous and pulmonary transpiration to the life and health of animals, went on to contend that in plants the transpiration from the leaves was the chief cause, aided by the pressure of the atmosphere of the motion of the sap. He then referred to the old but valuable researches of Stephen Hales, who demonstrated the importance, as well as the extraordinary power, of the transpiration of plants, and explained the frequent blight in hops and other plants by the action of an atmosphere saturated with moisture, and therefore unfitted to support transpiration, in suppressing the transpiration from the leaves, and thus arresting the motion of the sap, which then putrefies, and leads to the death of the plant. The putrid sap becomes a fertile soil for the seeds of microscopic plants, fungi, &c.; and these are further propagated by seed, so that the soil may become infested by them. Liebig then proceeded to contend that the potato plant was one of those which, like the hop, suffered greatly from suppressed or impeded transpiration; and that potato rot had long been known, and was even very accurately described by Parmentier,* who introduced the potato

* I think Professor Liebig was mistaken here, and that it was the dry rot of Martius that Parmentier described.

into France; but that the peculiar atmospheric condition to which he ascribed the disease had never till of late years occurred over whole countries, but only locally. He considered the real cause of the disease to have been an atmosphere loaded with moisture and cold, those being the conditions most favourable to evaporation; and he showed that in 1845 and 1846, when the disease overran Europe, damp, cold, and rainy weather followed heat and drought, just at the period of the most luxuriant growth of the potatoes. This state of the atmosphere he considered to be the same as that which caused influenza in the human subject, by suppressing the cutaneous transpiration. He further showed that the very life of a plant depended on the resistance it offered to the destructive influence of the atmosphere, and that the life and health of the plant depended on the equilibrium of external causes, only one of which—the state of the soil—is much in the power of the agriculturist. One day, or a few degrees of cold, may be decisive as to the life or death of a plant, so that it is of the utmost importance to strengthen the plant so as to enable it to resist the external influences tending to destroy it. Now, Dr. Klotzsch came to a similar conclusion, and showed that as the potato was cultivated for its tubers there was a loss of nutrient matter if it be allowed to form flowers and fruit, and he concluded if that were prevented the nutrient matter would be sent into the direction of the tubers and roots, and thus the plant would be strengthened and enabled to resist disease. He proposed, therefore, when the plants were from 6 to 9 inches above ground to pinch off the ends of the stem and branches for half an inch only downwards from the point, and to repeat this four weeks later. In some experiments made by him, in which the alternate rows were treated in this way, the result was that the rows not so treated were straggling and sickly and had scabby tubers liable to disease; while the rows so treated were bushy, luxuriant, dark green, with very numerous tubers, clean and free from all disease whatever. The process was said to cost only 1*s.* 6*d.* per acre in Germany. The Prussian Government agreed to give Dr. Klotzsch the sum of 300*l.*, if at the end of three years it was found effectual. But whatever might be thought of the remedy, or however fair or deserving a subject of experiment it may be as to the general strengthening of the

potato plant, the alleged cause seems a great deal more than doubtful. To say nothing of grave physiological objections to it, the very facts on which it rests are contested. 'A diminution of the temperature of 6° or 8°,' remarked Mr. David Milne, 'is exceedingly trivial, and must have occurred in former years when the disease did not occur.' Nor is the potato plant of so delicate a nature as to be unable to stand much greater diminution and irregularities of temperature than those which occurred in 1845. The fact that it grows equally well in the Shetland Isles with a temperature of 46·3°, and at Blackheath with an average temperature of 56·7°, or 10½° of difference, or even in hothouses with a temperature of 20° or 30° higher, must satisfy any one that the temperature of 1845, though undoubtedly lower than usual and irregular in progression, cannot account for the failure. The heat of 1846, too, when the disease was more virulent and extensive than in 1845, instead of being below the average was actually a little above it; and the fall of rain, as ascertained at a great many places, though unusually fitful, and sometimes exceedingly heavy, was not, as a whole, much above the average, and did not anywhere produce an excess of cloudiness or any material excess of moisture. The theory, which was advanced by a German, that the disease was produced by an absence of magnesia in the soil was not generally received; besides, it ought to have been found that crops grown on the magnesian limestone were less liable than others, but I believe such was not the case.

The following theory, which may be called the chemical theory, and which has been so well developed by Schleiden that it may be called the Schleidenian Theory, may be stated as follows:—The external wall cell consists of cellulose —a substance void of nitrogen, which, as long as it is pure, resists decomposition very powerfully, but its substance, after a time, is impregnated with other matters. This is lined with a coat of various thickness, but of far more yielding texture, containing nitrogen in abundance, in consequence of its involving proteinous matter. The cavity meanwhile is filled with fluid, which consists of various substances—some, like protein, containing nitrogen; others, like sugar, gum, &c., in a soluble form, free from nitrogen; while numerous solid bodies float in it, as starch, inalin, &c., which are also combinations

of oxygen, hydrogen, and carbon. In order that life may be carried on with vigour, the nitrogenous portion must bear a proper proportion to the substances which are non-nitrogenous. As the plant grows old, the original cell wall is impregnated with proteinous matter, and becomes at last incapable of performing its functions. Now, in every case of disease, as was observed above, the first symptom is a darkening of the proteinous lining; its texture becomes altered; and, finally, it involves the cell wall so as to make it unfit for a normal reaction on the contents of the cells. The cells themselves and the matter they enclose, whether belonging to the dextrin or protein group, depend on the inorganic matters they receive from the ground; and, if these are not properly proportioned, disease takes place. The proteinous compounds depend on phosphates, the dextrinous on matter free from phosphorus, and the phosphates are comparatively rare in nature. Under cultivation, especially where much animal manure is used, they exist in large proportion in the soil, and in consequence, as plants cannot choose their food, an abnormal condition takes place; and the more phosphates are relatively increased in any soil, from the mode of accumulation and cultivation, the more the plants which it produces have a tendency to deviate from their original type, to form varieties and sub-species, and, finally, to be attacked and destroyed by internal disease.

Now potatoes contain a great deal of starch and water, with very little proteinous matter. All such matter, however, when in solution, is easily subject to putrescent decomposition, involving more resisting substances, such as starch and cellulose in decay. It is easy, then, to see how dangerous any marked increase of the admixture of proteinous matter may be to health, &c., &c.

The above theory was not thought very much of by Dr. Voelcker and others at the time it was published, and Dr. Voelcker, writing in 1856, said, with regard to this, in Morton's 'Cyclopædia of Agriculture:'—

It is not our intention to enter into a discussion of the various theories which have been proposed with respect to the cause or causes of the potato disease. Notwithstanding the painstaking exertions of multitudes, and the laborious investigations of many, to discover the causes of this calamity; notwithstanding the ingenious theories and the host of treatises, which alone would fill the shelves of a small

library, it must be confessed that we have not far advanced in the positive knowledge of the true cause of the potato disease; and that, for this reason, the remedies which have been recommended to counteract its ravages have all failed, more or less, to put a stop to the evil. When all men were eager to favour the world with a new theory on the potato disease, chemists were not found slow to communicate their views on the subject, and to suggest numerous remedies; but, unfortunately, neither their chemical explanations of the causes of this disease, nor their remedies to overcome it, have been more successful than others. Several chemical theories have evidently been drawn up hastily, and are contradictory in their statements; and as even the best of them have shared the fate of many other theories, and in our view have done much towards bringing agricultural chemistry into disrepute with practical men, we think it better rather to leave the chemical theories in well-merited oblivion, than to revive them by discussing their faults. We would observe, however, that there is no material difference in the composition of the ash of diseased and sound potatoes; and that, for this reason, the cause of the disease cannot be attributed to an alteration in the relative proportions of inorganic matters which enter into the composition of the potato. This appears decisively from the following analysis:—

Analysis of Sound and Diseased Potatoes.

	Sound Potatoes	Diseased Potatoes
Phosphoric acid	14·81	14·73
Sulphuric acid	4·14	5·20
Silicic acid	3·20	4·16
Chloride of potassium	10·91	9·96
Chloride of sodium	traces	traces
Oxide of iron	0·44	0·92
Magnesia	3·67	2·64
Lime	2·06	1·33
Potash	48·75	49·2
Oxide of magnesia	traces	traces
Carbonic acid	10·58	9·86
Charcoal, sand, &c.	1·62	1·24
	100·18	99·24

And my friend Professor Church, late of the Royal Agricultural College, informs me that no chemist of the present day would think of bringing forward such a theory; so there is an end of it. One writer attributed the disease to the emanation of a more than ordinary quantity of nitrogen from the soil, to correct which it was recommended to plant cabbages

between the rows of potatoes as great consumers of that element; but, although potatoes planted in that way were found, in some instances, less injured than others, the immunity might readily be attributed to other reasons, such as the greater room for air and light to the plants.

The disease has, by some persons, been attributed to degeneracy of the tuber from improper storing. There is no doubt that great care is necessary in storing the tubers. It was quite necessary before the disease appeared, and is now more so than ever. If potatoes are put away, some of which are in an unsound state, mixed with others which are sound; if the storing pit is at all damp, the disease will be sure to extend through all, and render the potatoes worthless; and that change is likely to take place even if they have been kept dry for several months and become damp afterwards. I have frequently kept potatoes spread out on a floor in a dry room with portions decayed, and the decay has been arrested; but if they had been exposed at any time to damp for a week or two, the disease would have spread to the other part of the tuber, and also to any other sound tubers with which they came in contact. It is of the greatest importance, in storing tubers for seed, to be very particular in keeping those dug from a patch which you know to be perfectly sound, distinct from any others. I would not store them even in the same building, or bring them in any way into contact with diseased or doubtful produce. This recommendation has never been properly acted on, and it is necessary to call particular attention to it now. The use of strongly azotised manures has been suggested by several as a cause of the disease. There is no doubt that the disease is, in many cases, much increased by the use of strongly azotised manures, or by the application of ordinary stable manure. It is difficult to know what to do in poor, dry soils. If no manure is used the crop is indifferent; and, on the other hand, if stable manure is applied immediately before the crop, there is a much greater risk of loss. It is a safer plan to manure well the previous crop, or put the farmyard manure on in the autumn, or use only potash salts in the spring before planting the potatoes. Here, again, the spread of the disease is confounded with the origin of it. The farmyard manure has a tendency to encourage the growth of many of the fungoid

family, particularly in warm, damp weather; but the seed or germ must be there beforehand; and, with regard to a particular state of the atmosphere as a cause, that has been referred to before.

Therefore, with regard to the theories of the disease having been caused by the degeneracy of the tuber from improper storing, or the use of strongly azotised manures, or a particular state of the atmosphere, the persons who advanced those theories ought to have shown that the disease commenced where those malpractices were carried on, or that a peculiar state of the atmosphere prevailed; but they did not do so. At the Academy of Sciences, in Paris, November 17, 1845, M. Boussingault communicated an extract of a letter from M. Joachim Acosta, of Bogota, relative to this disease. It appeared from the letter that the disease was very common in the table-land of Bogota, in Columbia, South America; that it was destructive in wet seasons, or even every year in damp spots. This did not prevent the tubers being used when the affected part had been removed. It was known that potatoes were indigenous to that plain. M. Acosta did not doubt that the malady had always been known there, since it excited no alarm in the Indians, who lived principally on potatoes. Now the disease having always existed at Bogota, and as the potatoes are never stored—and, no doubt, no trouble ever taken to manure them—all the theories as to the disease having arisen from the degeneracy of the tuber from storing, or the use of strongly azotised manures, came toppling to the ground; and, with regard to a peculiar state of the atmosphere, there must have been something remarkable about the state of the atmosphere on the plain of Bogota for hundreds of years previously to 1840; but about that time this extended to the United States and Canada, and gradually spread to the United Kingdom of Great Britain and Ireland, to the continent of Europe, and finally to every quarter of the habitable globe; and this peculiar state of the atmosphere has remained till this day. The idea is really too ridiculous to be seriously entertained, particularly when the whole thing can be easily accounted for in consequence of the introduction of a few tainted potatoes, as will be hereafter shown.

CHAPTER III.

Theories which have been advanced to account for the Origin of the Disease—(continued).

Some years ago, soon after the disease appeared, the editor of the *Gardener's Chronicle* had so many different theories sent to him as to the origin of the disease, that he got out of patience with them, and published the following notice:—

'We foresee an inundation of theories as to the cause of the potato disease, which every one finds himself capable of explaining, except those who have most information about it. We may, therefore, save the time of our readers and correspondents, as well as our own, if we take this early opportunity of expressing our intention of not giving any insertion to any speculations upon the subject, unless they involve new matter, and are supported on authenticated evidence.

'The following causes for the disease have already been suggested:—1. The bad season of 1845. 2. Attacks of parasitical fungi. 3. Insects or worms. 4. Frost. 5. Lightning. 6. Exhausted vitality. 7. Bad cultivation. 8. Guano or other manures. 9. Miasmata, such as produce cholera in man, and murrain in cattle. The last—an unknown cause by an unknown agency, the action of which in the first instance is beyond human perception—may be taken as the last and best refuge of theorists, for it is alike incapable of proof or disproof. Of the remainder we shall only say that they appear to us to be all untenable. Even the season of 1845, which seemed to us and so many others peculiarly suited to bring on the infection, we long ago disclaimed as the true cause; for irresistible evidence to the contrary accumulated during the winter. In fact, no theory of the potato disease will satisfy the conditions of the problem unless it explains the following unquestionable facts:—

'1. It has for some years past been violent at St. Helena.

'2. It appeared in the year 1845 at Genoa and Lisbon, and

at Grahamstown in the Cape Colony, exclusively in potato crops obtained from English "seed," and therefore of the growth of 1844.

'3. It appeared in 1845 in the Bermudas in fields cropped with potatoes obtained from the United States, and not in those cropped with Bermuda sets.

'4. It has broken out in Australia, upon the authority of Dr. Francis Campbell in a letter to the *Sydney Morning Herald* dated March 18, 1846.

'5. It was little known in bog or moss land in 1845, and has now broken out there with as much violence as elsewhere.

'6. It is accompanied by an increased excitability of the potatoes, both young and old.

'7. It invariably begins in a brown decay of the bark of the potato stem under ground, and an inch or two above its origin from the old set. To this we have never yet found an exception; all the blotching and searing of leaves are long posterior to this.

'8. It has broken out at this moment (August 12, 1846), in crops obtained on well-drained, unmanured land, from sets imported from Naples, the Azores, Oporto, and New Grenada, every one of which places was reported to be uninfected.'

This article exercised a decided check on the writers who advanced theories to account for the origin of the disease. The challenge here given was never taken up, and, as far as I know, the questions have not been answered to this day; but I see no difficulty in them, and I will now reply to all the queries. But, before I begin, it is necessary to prove that the disease may be produced from planting unsound tubers, and that it is then capable of spreading in other ways.

In the Commissioners' Report (see Appendix) Mr. J. M. Berkeley said that he had tried some experiments with potatoes with the mycelium or spawn of the fungus in them, and that it did not necessarily follow that they should produce a diseased crop unless the conditions were favourable to the growth of the fungus; and that accords with my own observations, for I have grown perfectly sound potatoes from seed which I know was not so; but although this evil consequence fortunately does not necessarily follow, it very often

does, as was experienced by several who planted potatoes in frames in the spring of 1846; the experience of Mr. Barnes, gardener to the Baroness Rolle, having attracted a good deal of attention at the time, as it was found that the disease of the previous year was liable to be continued. This question has been satisfactorily proved by the experiments of Professor De Bary, reported in an Essay in the Royal Agricultural Society's 'Journal' for 1875, in which he has shown, beyond the possibility of doubt, that diseased tubers will occasionally produce diseased shoots which mature Conidia, which are the means of spreading the disease to the sound potatoes. There is also another way by which the disease is capable of being spread—viz. by the resting spores. I think there is no doubt of their being a cause of the spread of the disease, although more information is still required with regard to them.

I will now proceed to the queries:—

'1. It has for some years past been violent at St. Helena.'—This might easily be the case. The disease had prevailed in the United States for several years before it reached this country. A cargo of potatoes, sent down one of the American rivers from the interior of the country, may have carried the disease to St. Helena.

'2. It appeared in the year 1845 at Genoa, Lisbon, and Grahamstown in the Cape Colony, in potato crops obtained from English seed, the growth of 1844.'—With regard to the two first mentioned places infected seed may have been sent there from the United States. With regard to the outbreak at Grahamstown in the Cape of Good Hope, there was a mistake here—the English seed was the produce of 1845, and not of 1844: the fact was overlooked that the season in the southern hemisphere is the opposite to ours. The letter from Grahamstown is given in full elsewhere.

'3. It appeared in 1845 in the Bermudas in fields cropped with potatoes from the United States, and not those cropped with Bermuda sets.'—This was only what was to be expected, but the latter part of the statement must be received with a certain amount of reservation. If the weather was very dry and not suitable for the extension of the disease, the produce of the Bermuda sets escaped for a time; but the immunity could not have lasted very long.

'4. It has broken out in Australia, &c.'—This was

probably from English seed, raised in August or September, 1845.

'5. It was little known in bog land, &c.'—Potatoes in that kind of land are not generally so bad as elsewhere.

'6. The earlier vegetation, &c.'—That is so with those partly infected. It would appear that those partly diseased are in a more excitable state.

'7. Invariably beginning with the bark of the stem, &c.' —Supposing the resting spores of the fungus grow and attach themselves to the stem of the potato, like the dodder does to the flax, this would be a very likely way for the disease to commence; but the fact is now well established that it often commences higher up.

8. 'On August 12, 1846, the disease broke out in crops obtained from sets from Naples, the Azores, Oporto, and New Grenada, places reported to be uninfected.'—This was only what was to be expected. No potatoes are free from the attack of the fungus. If you have a pure stock of seed to begin with, you escape for a time; but later in the season the disease becomes general if the weather is favourable for its extension, and all are liable.

The fact was, that at the time Sir Walter Raleigh brought the potato to Ireland, it had not then been attacked by the disease—or, what is more probable, that he brought over some tubers entirely free from it; but that for some years previously to 1845 the disease which had prevailed for many years in the central plain of Bogota, in the northern part of South America, was introduced to the United States, and, after prevailing extensively there, gradually worked its way down to the Coast, and, after it arrived there, spread to this country—in fact, it was impossible for us to escape. Tainted potatoes were sent over here with the spawn or mycelium of the fungus in them, and the disease produced here; and by means of the *conidia*, or summer seeds, as they may be called, and the *resting spores*, or winter seeds, it was spread to our own crops; and that, in my opinion, was the origin of the potato disease, as far as we were concerned. After it had once obtained a footing here, here it remained, as Professor Morren, of Liége, said would be the case, and we then became the means of scattering it over the various countries of the globe. If the commis-

sion which was appointed by the Government to inquire into the cause of the disease and the remedies to be taken for its prevention had been summoned earlier, when the disease first appeared in the United States, and sent over there and discovered the cause, it might have been prevented from coming here at all; but the importation of American potatoes would have had to be forbidden.

Seeing the result of previous experience, it appears to me that we are acting very unwisely in admitting American potatoes now. The danger of introducing the Colorado potato beetle is very real; and it is only from the circumstance of the beetle hybernating in the soil, and not in the potato, that we have not had it here long ago.

The reader may not doubt my conclusions as to the introduction of the potato disease, but may be desirous of ascertaining if there is any evidence which can be brought forward to support them; and, fortunately, there is by letters and consular reports. Now, if any evidence is required on any doubtful subject, nothing is considered more reliable than that of a consular report. It is a serious document sent by a member of the Government abroad to the Government at home. It so happened that the Government obtained a series of these reports. The object was to ascertain in what countries there was no disease; because it was thought, if seed were procured from countries entirely free from it, that it would escape the disease here. This was not found to be the case; so the inquiry was of no use in that respect; but it is of great service to me now in enabling me to prove the existence of the disease in the United States, and its spread from that country to others. Mr. Peters, Her Majesty's consul at Philadelphia, United States, wrote, December 30, 1845, that the disease was very general in Pennsylvania in 1843, and continued to prevail in 1844 and 1845, but only partially. Mr. Barclay, at New York, stated, January 10, 1846, that the disease existed in that quarter in 1843, 1844, and 1845. Mr. Grattan, the consul at Boston, reported that it began in Massachusetts in 1843, increased in 1844, and became very general in 1845.

Colonel Reid, the Governor of Bermuda, reported that the disease had reached that station, and added that in every case in which it had occurred it had been in imported seed potatoes from some part or other of North America. The

evidence on which his opinion was founded was contained in the following extracts from returns obtained from various cultivators in the island:—John M'Gall: An imported American blue potato was much infected with disease when landed, which began to appear when the crop was about half grown.—Francis Peniston: I had five bushels of black kidney potatoes sent me last year, from New York, for trial. On opening them they were found much decayed, and were supposed to have been from a diseased crop. The parts which appeared sound were cut off and planted, but many of them failed. Those which made their appearance above ground, came to maturity, were good, and kept well.—John A. Skinner: Last year a part of my potatoes were attacked by a disease which caused the haulm to die off when about two-thirds grown. The seed came from Prince Edward's Island.—James W. Tudor Boyle: The potatoes (pink eyes) were imported from the United States, December, 1844, being then in a perfectly sound state. They sprang up quickly, and from their flourishing condition an unusually large crop was expected. About sixty days after being planted, they began to be diseased, until the whole were decayed.—Augustus Wm. Harvey: A gentleman imported from New York twenty-seven bushels for seed. They appeared to flourish beautifully for eight weeks, when they suddenly began to droop, &c. He only dug six or seven bushels, the remainder being of good size, but perfectly soft and rotten.

Copy letter from the British consul at Warsaw, Poland, to Lord Palmerston, October 16, 1846:—

'My Lord,—In a report on the result of this year's harvest in Poland, which I had the honour to forward to your lordship with my Letter Consular No. 25, of the 28th of last month, I stated that the potato disease was totally unknown in this country.

'Since making that statement, I have heard of an exception to the rule, which has occurred on a small estate not far from Warsaw, farmed by a Mr. Kedzlie, a British subject of much intelligence, long established in Poland.

'The potatoes which have furnished this exception are of the kind called ash-leaved English kidney potato, and were obtained from England; they were planted in the midst of Mr. Kedzlie's other potato crops on land of the same

quality, and prepared in exactly the same manner as the rest of the ground, which has yielded perfectly sound tubers.

'This circumstance would seem to prove that the disease is not attributable to atmospheric influence, as is, I hear, the generally received opinion in other countries. Here, in Poland, all persons to whom I have spoken on the subject think that the potatoes in the rest of Europe are tainted in the germ by over-cultivation; and it is certainly remarkable that here, where the soil is generally light, and where less manure is used than in any other country, except Russia, and never immediately preceding the crop of potatoes, those plants should have completely escaped the infection which threatens their extinction in all parts where greater pains have been taken in their cultivation. I do not imagine that the opinion alluded to in the isolated fact which I have mentioned will decide a question which has so hopelessly occupied the attention of first-rate scientific men in many countries; but I hope that the notice of the circumstances will not be deemed irrelevant at a time when the disease in question is the cause of such dire distress in Her Majesty's own dominions as well as in other parts of Europe.'

December 29, 1845.—Her Majesty's consul at Lisbon reported that the few potatoes affected in the neighbourhood of Lisbon were grown from seed received from England.

Potato Disease in the Cape of Good Hope.

Extract from a letter in the *Grahamstown Journal* of January 31, 1846:—'On September 28 last I planted a bushel of potatoes of the kind known in London as Shaws, one bushel of Americans, one bushel of reds, and one bushel of ash-leaved kidneys. All these, with the exception of the kidneys, were imported from England not long before they were planted; the manure applied to them was stable manure. Up to the end of October they were strong and vigorous. All at once the Americans began to yellow in the leaf, and, upon examination, I found the stems close to the ground had shrivelled up. In fact they had all the appearance of having been hardly pressed between the finger and thumb. For two or three weeks they went on in this state, being anything but pleasant to look at. At last I determined to uproot

them. Fancy my astonishment to find at least a fourth of the full-grown tubers completely rotten, and at least a half more all but covered with dark blue spots! I caused them to be spread out on the surface under the influence of an African sun, which so completely dried or roasted them that in the evening the diseased parts fell off in little, hard scales, leaving the tubers sound beneath; and to this day they are so, now nearly a month since. That the disease was brought to this colony by the seed I have no doubt—at least, the causes ascribed in England cannot be ascribed here. In the month of September we had only two showers after the potatoes were planted, in October two, and in November only one. As for sunshine, there was enough of that to make an Englishman feel rather queer.—R. J. SMITH, the Oaks, near Caledon, Cape of Good Hope.'

Many other reports might be added to these by searching for them, but I hardly think it necessary. Three British consuls testify to the existence of the disease in America before it was known here, and others certify that it was introduced from England to other parts of Europe, Australia, &c.

CHAPTER IV.

Fungoid Theory.

HAVING brought forward and reviewed all the other theories which have been advanced to account for the disease, and having found them wanting in some point or other, I have discarded them, and only one remains—that is, the *fungoid theory* of the disease. During the course of my investigations into this subject, I have not met with one single fact which is inconsistent with this theory. Mr. Berkeley, writing in 1856 in Morton's 'Encyclopædia,' although inclined to the fungoid theory himself, stated two theories—viz. the fungoid, and the Schleidenian—and gave particulars

and information with regard to each; and left the reader to draw his own conclusions, although he admitted there were difficulties in the fungoid theory then unexplained. I believe these difficulties have all vanished now; and, the Schleidenian theory being upset, there is no other left except the fungoid theory, which has, for some time past, been almost universally accepted by scientific men as the true cause. But many of the potato growers have not been by any means convinced, and all sorts of things are being continually written not at all in accordance with this theory, and some writers are directly opposed to it; but I think that has principally been because the entire question had not been thoroughly gone into, and the results properly laid before them.

From the very first appearance of the disease, it was spoken of as a blight; and there is the almost universal dark spot on the leaf, which, if looked at with an ordinary magnifying glass, reveals the presence of a fungus or mould, and this fungus or mould is always present whenever there is disease; in fact, it is the destructive effect of the fungus which we see whenever the stem or the tuber decays. If you have a potato which is slightly touched with the disease, you have only to place it in a damp place, and you see the growth of the little mouldy tufts of the fungus. There are doubters who admit all this, but say the potato must first be in a diseased state, and then it is attacked by the malady. But, with regard to this, all the evidence is the other way; and it would not account for the malady first appearing in 1845; and it is really nothing short of ridiculous to suppose that in that year there was an unhealthiness in the plant, which had not occurred for the previous two centuries. Besides, seedlings raised from the potato apple are equally liable when planted out near others suffering from the disease.

I will now explain a few of the phenomena with regard to the disease referred to in the earlier part of this treatise. In the first place, I believe the reason why the disease appeared earlier in the Isle of Wight than in more northern districts of this country, was on account of the earlier vegetation of the potato there. When the disease is communicated to a crop in consequence of a tainted potato having been planted, the earlier the vegetation the earlier the growth of the fungus, although the disease, once started, spreads in

other ways. I regarded the outbreak near Liverpool, not to its having spread thus far from the southward, but to some tainted tubers having been introduced there, and thus become a new source of contagion. Again, some of the islands which were out of the general traffic between America and this country—such as the Scilly Islands, the Calf of Man, and the Shetland Isles—escaped in 1845; and this escape is to be attributed to their not having had any tainted potatoes landed there the year before; but this immunity did not last, because unsound tubers were sent from England to them in the following season. Again, with regard to the occurrence of the disease in some greenhouses in Jersey, thus referred to by Mr. Bréhaut in the *Journal of Horticulture* for 1872:—'On digging up our early potatoes in the orchard house borders, about the middle of April, we were surprised to find one-tenth diseased—a thing which had never previously occurred. The haulm was perfectly healthy and the tubers fine, planted in two separate houses. It is difficult to assign a cause for this, as potatoes under such conditions are apparently removed from electrical disturbances, from abrupt atmospherical changes, from currents laden with poisonous germs, and from excessive moisture, some of which are held by observers as predisposing causes.' He was at first disposed to attribute the cause to the seed; but he finally remembered that a new garden walk of some extent had been made, and some of the soil was added to the two orchard house borders; and this soil had previously borne crops of potatoes. Now the introduction of this soil, which was probably filled with the mycelium of the fungus, was quite sufficient to account for the presence of the disease in this case, without calling into aid the resting spores; but with regard to the tops of the potatoes remaining unaffected, which he said was the case, he does not appear to have examined them with the microscope; therefore this statement must be received with a certain amount of reservation. Although, perhaps, nothing visible to the naked eye, the presence of mycelium in the stems might have been detected on a more careful examination.

The potato fungus is what is called a parasitical fungus; that is to say, it is incapable of an independent existence, and has to live on some other plant in the same way that the mistletoe does on the apple tree; and its natural home is,

unfortunately, the *Solanum tuberosum*, or edible potato; and, although it has been known to live for a short time on some other plants, it is doubtful whether it could continue its existence very long in the absence of the edible potato. This fungus was very soon observed and described on the appearance of the disease, and was called by botanists *Botrytis infestans*, which was the name it was known by for many years. In 1872 it was classified by Montagne with a small family of fungi called Peronosporæ, and was called *Peronospora infestans*.

Professor de Bary, in his essay a few years ago, proposed to call it Phytophthora for the following reasons:— Phytophthora is distinguished from Peronospora in having, not one, but several conidia, successively formed at the end of each branch of the tree-like Condiophore. When the first conidium is ripe, it is pushed to the side by an unequal swelling of the point to which it is attached. The top of this swollen portion then begins to grow, in the original direction of the branch, into a new conical point; and, when this has reached a length equal to that of a conidium, or a conidium and a half, a new conidium is produced at its apex. The same process may be repeated, in vigorous specimens, ten or fifteen times. After the falling of the very easily shed conidia, as many swellings remain on each branch of the Condiophore as there had been conidia. Such swellings do not occur in the stems of the true Peronospora, but are a sure empirical character in the Phytophthora. He, therefore, proposes to call the potato fungus the *Phytophthora infestans*. Whether the latter name is likely to be generally received or not I do not know, but I think that these changes of name are rather to be regretted.

The first notice that the ordinary observer has of the presence of the fungus is the appearance of a few brown spots on the leaves of the plant, and then some of the stems seem to be affected, and afterwards a patch of the garden or corner of the field is black with them. The stain gradually extends down the stem of the plant and over the haulms throughout the garden or field. Next, the pollution finds its way to the tubers, the foliage dies, and the air is poisoned with the rank exhalation of the rotting vegetables. The above is a popular description of what is generally seen; but those

who have examined the potato plant with a microscope find that it occasionally commences with the stem. In such cases the first external appearance of the disease in the stem is marked by a deepening of colour, accompanied by an enlargement of the affected part, and succeeded by a weeping or exudation. As the disease advances, the part of the stem affected becomes soft and pulpy, and the colour changed to a yellowish-brown. The stem is generally, if not universally, first affected at a joint, or the part from whence a lateral branch springs; and the leaves above the diseased part turn black, droop, and die. Mr. Phillips thus wrote of some potatoes that he examined with the microscope:—'The plants were forwarded to me by a gentleman of great practical knowledge; and better specimens for the purpose could not be desired. The stems were all connected with the parent sets; so that I had foliage, stems, young tubers, roots, and sets complete. The upper part of the stems and leaves of the diseased plants had the dull and heavy appearance so characteristic of the disease; and nearly the whole of the stems were more or less affected at one or other of the joints whence the lateral branches sprang. In some of the plants the stem was most affected at a particular joint; in others, the smaller branches and leaves were most injured. No trace of fungi or insect was discoverable in some of the affected stems beyond the immediate localities of the diseased joints. The disease, in those cases, had not extended itself, and was confined to a space not exceeding one inch in the length of the foot-stalk. In other cases, the disease had spread both ways for a considerable distance from the wound, confining itself chiefly to the medulla (the pith of the plant). Fungi of the boleti and stellate kind were observable in all the diseased stems; and, at parts where putrescence existed, the mycelium of the potato fungus abounded. The stem of one of the plants was hollow, the medulla having apparently lost its vitality and died away. The hollow part extended to about three-quarters of the length of the stem from the root upwards. On examining the stem by thin, transverse, and longitudinal sections, I observed that the vessels which traversed the walls of the cells were filled with a rich, brown-coloured, fibrous mass, the form of which could only be distinguished at the angles of the cells severed by the cutting. The vessels also contained

fungi of a similar colour to the fibrous mass arranged in a star-like form; these masses of fungi had pierced the walls of the cells in some instances, and appeared approaching their centres. The colour of the fungi imparted a tinge to the cells, so that the most diseased ones appeared brown. One of the plants examined contained two diseased and one sound stem; the stems were attached to the sets, and young tubers were formed on some of the stolons. I dissected the whole of the stems, and traced them microscopically downwards to the parent set. The two diseased stems sprang from separate germs; one of them from the crown or principal eye, and the other from an adjoining lateral one. The sound stem originated in a germ somewhat lower in the tuber. On dissecting the old tuber, or set, I discovered that the two diseased stems were the offspring of diseased germs, and that the sound stem sprang from a sound germ. Previously to dissecting the old tuber or set, I carefully examined it, but could discover no trace of disease from its external character. The cuticle was clean and healthy; and no external examination could possibly have detected the disease existing among the germs. The state of the set indicated the disease to have existed from the last season, for the infected parts were deep seated; and, as no abrasion of the cuticle could be found in any part of the tuber, its origin could not proceed from any external or outward influence acting on the set.' Another tuber or set, to which two stems were attached, contained one sound and one diseased stem, which he as carefully and microscopically examined as the former one, and with the same results. The diseased stem sprang from a diseased germ, and the sound stem from a sound germ. He continued his examination of the remainder of the plants, and found all the same. Now here we have a case, which is plain enough, of the disease being produced in consequence of planting tubers which were not sound, though apparently so. The date was not given when these potatoes were dug from the ground, nor the variety mentioned. It must have been early in the season; for the old sets would have decayed if they had been long in the ground, and the young tubers were but little developed. Now, to make these observations more complete, they ought to be contrasted with some, made later in the season, with plants which became affected by the disease passing from other

potatoes to them. Plants of this description have, no doubt, been examined with the microscope; but I am unable to refer to any with certainty. I had plenty of specimens which answered this description, raised from perfectly sound tubers and from potato apples; but the desirability of examining them microscopically, unfortunately, did not occur to me until too late. I had some seedlings which I know caught the infection from others; and, as far as I could see, they were affected in a very similar manner to those above mentioned. Sometimes the leaves appeared, to the naked eye, the first part affected; in other cases a portion of the stem was affected at a joint before the leaves above it were. They were nearly all affected in more than one stem, and the disease gradually spread over the whole plant, and, ultimately, extended to the tubers.

When the fungus once gets possession of a potato plant in damp weather, it generally grows and spreads over the whole of it, and throws out branches which produce conidia, which are the means of extending the disease to others; but when it has progressed very far, it so interferes with the flow of sap through the stem and branches that the leaves droop for the want of nourishment, and finally the whole plant dies.

On the decay of the foliage, and when the tubers have been gathered, the fungus disappears from the field, and does not appear again till next summer; generally not when the young foliage appears, but about the time of the blossoming of the potato, or even later. The question then arises, Where does it remain in the period between its disappearance and its reappearance? how and where does it winter? and how does it pass from its winter quarters to the foliage of the potato?

Professor de Bary says, with regard to this:—'In the first place, it is clearly established that the conidia have a very short existence, and are incapable of living through the winter. From what is certainly known about all other Peronosporæ and also about Saprolegnieæ, we can only look to resting spores which endure through the winter, and to perennial mycelium, for maintaining the life of the fungus. It has long been known that perennial mycelium frequently occurs in the tubers; and to this point I shall again recur. Resting spores have not been observed in Phytophthora; but from analogy

it may be taken as certain that they may somewhere occur. The discovery of them would at once fill up the gap both in the morphology of the fungus and of the practically important question of how it hibernates. And, accordingly, ever since the resting spores of a Peronospora were discovered, innumerable searches have been made for those of Phytophthora. I have myself looked for them for fifteen years, and on every opportunity have searched for them in the stalks, leaves, flowers, fruit, and tubers of the potato. In July of the present year (1875), when the fungus appeared in this district in sad abundance, I obtained a very large amount of material for study, and, at the same time, secured the kindly assistance of two botanists experienced in researches of this kind; but again only negative results were arrived at.' Now, about this time (July 22, 1875), Mr. Worthington G. Smith contributed an article to *Nature*, stating that he had discovered the resting spores of the fungus; and wrote further on the subject in the *Gardener's Chronicle*, describing specimens, with illustrations, &c. Professor de Bary criticises the drawings and also the remarks of Mr. Smith, at considerable length, in his essay. It is unnecessary for me to go further into the question here, or make any long extracts; it is only necessary to say that it does sometimes happen, that an object which has been looked for a long time by one person without success, is found by another; and that the general opinion in this country is that Mr. Smith was right, and can only attribute the want of success on the part of Professor de Bary in not finding the resting spores, to his having passed them over. He must have seen them, but mistaken them for something else.

With regard to the resting spores, I have no doubt more information will shortly be obtained; and it would, I think, be quite possible to prove their presence by experiments carried out with that object in view.

CHAPTER V.

The Disease in America.

THE importations of agricultural produce from the United States to this country have for some years past been gradually increasing, and have now assumed such gigantic proportions, and at so low a price, that it really has become an important question for us as to whether there is any crop in existence which can be grown here with profit, or whether we must abandon the field altogether to the Americans.

The climate of the United States is not very well suited to the growth of the potato, and the farther South they are grown the worse the crop. The sun is too powerful, and causes the potato to produce many more long and slender stems than in England; and in some soils the tubers are of inferior quality. The disease, too, prevailed at one time extensively, and considerable losses were suffered in the States of New York, Maine, New Hampshire, Massachusetts, Vermont, Michigan, and Ohio, and other States, and the losses were very serious; and it is doubtful whether the price in America has been so low as it was before the disease made its appearance, until, perhaps, the present year in Canada, and that in exceptional cases.

The disease was well known, and had attracted a great deal of attention in New York and some other adjoining States, in 1843; but I believe it prevailed earlier in the Western States. It is an interesting subject of inquiry as to what was the origin of the disease in America; it carries one back a long way into the past, in fact, nearly as far as it is possible to go—to the dawn of creation. Things must have had a beginning; and, as few persons now have any faith in the theory of spontaneous generation, and no proof has ever been given of the starting into existence of new plant life not before known, there is every reason to suppose that the fungus was always in existence. I have no doubt in my mind that the disease existed amongst the wild plants of the

Solanum family, on the western coast of America, before the potato (the *Solanum tuberosum*) was cultivated, and before man appeared on the scene; and, as if in confirmation of this, a fossil fungus, nearly allied to the Peronosporæ, was discovered by Mr. J. Butterworth, of Oldham, in the Palæozoic rocks, and was described by Mr. Worthington G. Smith, and named by him *Peronosporites antiquarius*.

About two years ago I wrote some articles in the *Horticultural Journal*, in which I suggested that it was possible, from the northern extension of the beautiful Humming Birds and many of the plants and animals on the western coast of America, that the disease might have existed amongst the wild plants of the Solanum family in the neighbourhood of Colorado, and that it might have been introduced from the Western to the Eastern States in the same way that the Colorado beetle was. The potato beetle had long been known to naturalists, and was discovered more than fifty years ago by Léon Say, feeding on a plant called *Solanum rostratum*, a poor relation of the edible potato growing on the eastern slope of the Rocky Mountains; and there it would have remained till this day but for the gradual spread of the emigrant and the cultivation of the edible potato, which afforded it the means to transfer itself from the uncultivated to the cultivated plant, and from the wilds of the Rocky Mountains to the cultivated plains, and from the Eastern States of America to the Western States, and from the Western States to Canada, and thence to Europe.

Since then I have made inquiries in America, and endeavoured to procure books and newspapers, from which information might be obtained with regard to this, and consulted the best living authorities there, and have succeeded in tracing the disease as far west as Wills County, Iowa, but am unable to trace it further. To find out where the disease first began in the United States would involve a journey to America. At this early period, the Western States were very sparsely settled, and the population so few that they were unable to support any journal to which reference could be made, with the exception of the *Union Agriculturist and Prairie Farmer*, started in 1841, the name of which was, in 1843, changed to that of the *Prairie Farmer*. There are several references to the disease in this journal, but they principally apply to its

existence in England and other parts of Europe. Whether the disease, therefore, came to the States from the West or the South-West is unknown; but, the disease having been known to exist at Bogota and other places on the western coast of South America, I must, in the absence of better evidence, admit that it was more probably introduced from the South-West to the United States, and not unlikely by the traders on their way through Texas. However this may be, there was a great outbreak of the disease at this time, and it spread over the United States, California, Canada, Argentine Republic, &c.; and it is my opinion that the cause may be fairly attributed to the settling up of the country, and the great impetus given to traffic all over the world by the comparatively recent introduction of steam-ships, railways, and other improved means of locomotion.

The following table, prepared some years ago by Mr. Seaman, an American gentleman, gives the prices, in the United States, of potatoes, corn, &c. (the latter for comparison), from 1840 to 1846, before the disease had done much mischief there.

Prices of Potatoes, Corn, &c., per bushel, from 1840 *to* 1846.

Name of State	Potatoes	Indian Corn	Oats	Wheat
	s. d.	*s. d.*	*s. d.*	*s. d.*
New England States	0 10	2 9	1 4	4 8
New York, Southern District	1 0	2 9	1 4	4 8
„ Northern District	0 10	1 11	1 3	3 7
Pennsylvania, Eastern District	1 0	2 9	1 4	4 8
„ Western District	0 10	1 8	1 0	3 7
Ohio	0 8	0 10	0 8	2 3
Indiana and Illinois	0 7	0 10	0 7	2 0
Michigan	0 7	1 0	0 10	2 3
Wisconsin	0 7	0 10	0 7	2 0
Delaware and Maryland	1 0	2 3	1 4	4 2
Virginia, Eastern District	1 0	2 3	1 4	4 2
„ Western District	0 10	1 0	0 7½	2 1
Kentucky and Tennessee	1 0	0 7½	0 7½	2 1
South Carolina, Georgia, and Alabama	1 0	1 0	1 2	4 2
Louisiana and Mississippi	1 3	1 4	1 0	4 8
Missouri	0 10	0 7½	0 7½	1 8

I have no later table to refer to; but the price of potatoes considerably increased after that date, also the price of wheat.

The present price of potatoes on the eastern seaboard of America is from 1*s.* 9*d.* to 2*s.* a bushel.

Although the disease was well known in the States in 1843, at that time it had not got very firm hold, neither had it committed very great ravages before 1846—the period included in the table—although it subsequently became very much worse; and the price of potatoes at one time, viz. 1854, in Ohio and New York, was 16*l.* a ton, and at New Orleans 25*l.* a ton, or more than it ever was in England; but of late years, since the 'cute Americans have taken to growing the early rose and other new varieties raised from seed which ripen early, their losses by the disease have been very much less. Professor Farlow, of Cambridge College, Massachusetts, informs me that the disease still prevails in Massachusetts, but to a comparatively slight extent. During recent years there has been no well-marked epidemic. In 1875 (a wet season) the disease was prevalent enough for him to procure specimens without difficulty; but he generally had to make a personal search in order to procure them. The Americans are very much more afraid of the potato beetle than they are of the fungus. Dr. C. V. Riley, of Missouri, has published a little book on the Beetle, recommending various plans for the destruction of the pest, the principal of which is Paris green; but he hardly says a word as to the fungus. The idea occurred to me that the application of the Paris green might not only have the effect of killing the beetle, but also the fungus; but Professor Farlow says that, although the people who sell the Paris green pretend that it does, he has no faith in it.

Now, with regard to the question whether America can compete with us in the growth of the potato, there is the fact that the price has not been so much lowered by importation as that of many other articles; and the competition is more limited to a certain time of the year than is the case with grain—in fact, in the early part of the season, America is a large importer of potatoes from Bermuda to supply New York, Boston, and nearly all the other large cities on the eastern coast. Besides, the potato is, to a certain extent, a perishable article, and more bulky and costly with regard to carriage. We also possess an advantage so far in not having the potato beetle to contend with. This insect is very troublesome and destructive, and the Americans have fre-

quently to spend from thirteen shillings to a guinea an acre in clearing the plants of the pest. On the whole, I am of opinion, if we can keep away the beetle and reduce our losses by the disease, we can hold our own, and have not much to fear from American competition as far as the potato is concerned.

CHAPTER VI.

The Disease in France.

M. VILLE has published a small book on 'La Maladie des Pommes de Terre,' and the experimental plots at Vincennes, France, referring more particularly to the growth of the potato with certain artificial manures. M. Ville says, page 1:—

'The potato disease for nearly thirty years has invaded France, and has not ceased to excite to emulation the zeal of scientific men and practical agriculturists; but this question, to which is attached so many interests, still awaits a solution. All the efforts have arrived successively to knock themselves to pieces against the unknown which hides from us the cause of the evil. Science, with regard to it, is always reduced to the same speculations, and practice to the same groping in the dark. Nobody makes a salient hit; nobody gives any positive result; nobody can tell us, for a certainty, a possible way of preventing the evil, or at least of mitigating the evil.

'When one thinks that the malady which devastates the silkworms causes a loss every year of a hundred millions of francs in the Southern Departments, and that the malady of the vine has not had less serious consequences; when one can scarcely say to what extent a bad crop of potatoes troubles the economic arrangements of the most necessitous classes—one can understand that men of the greatest ability have given so much devotion in searching for the solution of this difficult problem. As for myself, I ought to say that I was accidentally drawn to occupy myself with potatoes; the

subject is, so to speak, imposed on me, rather than that I have sought it. Last year the disease made its appearance in the experimental field at Vincennes, in some places in the middle of many others that were spared.

'Until 1867 the malady had little devastated the experimental field at Vincennes. I am willing to admit even that I had only accorded a secondary attention up to that time to the losses which it had produced. I had remarked, however, that it devastated, in preference, those plots where the manure contained a strong proportion of azote, without being able to justify this opinion by the facts and figures.

'In 1867 things took place differently. The malady manifested itself with a totality of symptoms so decided and agreeing, that it became impossible not to be struck by it. In a band of soil cut up into contiguous plots of an *are* in size (about four perches), separated by a road a yard wide, the disease suddenly made its appearance in two plots, in exclusion, apparently, of all the others. Towards July 20 the leaves of these two plots began to be covered with spots, and a month later they were completely destroyed. At that time the other plots had only been slightly attacked. M. le Marquis d'Havrincourt said:—"In one part of the experimental field at Vincennes, one sees a patch of potatoes divided into five parts, touching one another. The first has not a leaf touched; the second is eaten up by the disease; the third is as good as the first, and the fourth is as bad as the second, and the fifth resembles the first and third. The contrast was, in fact, very surprising. At the digging time the state of the tubers justified the indication drawn from the state of the leaves. The quantity of bad potatoes was, for all that, not much; it rose from 15 kilogrammes from one plot to 105 from another, and 10 kilogrammes on the others; those which bore the bad potatoes from about 1,000 kilogrammes to 1,500 kilogrammes the hectare. They had a greenish colour; and the crop was, I repeat, half less than in the other plots."

'Here arises, very naturally, this question: What treatment had these two plots been submitted to? The one had not received any potash for eight years, and the other had never been manured. But these two conditions were not the only ones under which the disease manifested itself. There is pre-

sented a third case, where it put on a different character. One must not forget that I have said this plot which produced 28,000 kilogrammes the hectare (23,800 lbs., a little under 11 tons, to the acre), and of which the manure, exceptionally rich in potash, did not contain phosphate of lime. Very well; on this plot, where the vegetation was showing itself luxuriantly just at the digging-up time, there were more bad potatoes than in the two others. Their state of rottenness was even so advanced that it was impossible to exactly weigh them, and it is only by approximation that I fix it at 2,000 to 2,500 kilogrammes per hectare (1,700 to 2,124 lbs. the acre).

'The disease, then, is produced at Vincennes under two different phases: in one, striking the leaves and stems when the tubers are fully attacked; in the other, concentrating its efforts of destruction on the tubers alone, without any alteration being presented in the exterior parts of the plant; and the same state of things has been observed by the Marquis d'Havrincourt.

'The malady has then attacked in a decided manner the parts of the field which had no mineral manures; those deprived of potash; those which had no phosphate of lime, and exhausted soil, and consequently deprived of both. I think to the unfavourable influence resulting from the absence of mineral matters in the soil, one must still add the abuse of azotised manures as a cause.

'Must one then conclude, from these indications, that the malady of the potato is a question henceforth solved, and that science has positively said its last word? That is not my opinion. What occurs to me is less to draw a conclusion than to verify by experiments, in a great many cases, whether they are the expression of a general law; and, if one can decidedly, at last, by certain manures, prevent, or at least reduce, the effects of the malady.'

Now, with respect to the remarks of M. Ville, it is necessary to bear in mind that he was not making experiments with regard to the disease, but more particularly with respect to the effect of certain artificial manures on the crop. As to the result of his experiments, above referred to, he has omitted to state what was the previous crop, or whether all the plots were planted with potatoes obtained from the same place. Supposing they were not, and it so happened that plots

marked 2 and 4 were planted with tubers from ground where the disease had prevailed in the previous year, and the others were not, it would be quite sufficient to account for the alternate arrangement of the diseased plots which appeared so surprising; and the extension of the disease, in about a month afterwards, to the other plots is just what might be expected under such circumstances. With regard to the case where the tubers were attacked beneath the soil, and the tops apparently unaffected, I have read of something similar to this before, and attribute it to the powerful effects of the artificial manure. I feel sure that, in a dry climate like France, if only ordinary care were taken in the selection of tubers for planting, and the best mode of cultivation followed, the losses by disease need hardly enter into the calculations of the planter.

CHAPTER VII.

Does the Disease attack at a certain Stage of the Plant?

DOES the disease attack at a certain stage of the plant, or at a certain time of the year?

If I were to say positively it attacks at a certain stage of the plant; or, on the other hand, it does not—it attacks at a certain time of the year; in either case it would be wrong. The truth, as far as my observation has gone, lies between the two.

It would certainly appear, with regard to some plants and animals, that they are more delicate, and more liable to the attacks of certain diseases, in the younger stages of their growth, than when more mature; the constitution seems less liable to, and better able to resist, the attacks of disease at a later period of life. With regard to the potato, I doubt if this is entirely the case. It appears to me that the potato is more liable to be attacked by the fungus when just past the height of development, but has better resisting power at that period than when attacked at an earlier stage.

Professor De Bary says:—'From large experience, I consider it probable that Phytophthora grows more easily on a plant at the height of its development than on young stalks and leaves. It would be interesting, but not easy, to establish this clearly by experiment.'

Now it so happens that I have tried some experiments this year which may tend to elucidate this point.

In the spring of this year I decided to make a few experiments with seedling potatoes raised from the seed apples on a cucumber frame I succeeded in obtaining a packet of seed from Messrs. Freeman, of Norwich, and sowed it in a frame with some flower seeds early in April. The seed vegetated but slowly; and it was the end of May before I had a few plants ready to go out into the garden. Perceiving that but few seeds had vegetated, I sowed a second batch, the beginning of May, in the same frame. I planted out some seedlings from both portions in the garden as soon as sufficiently large for the purpose—viz. about three inches high—not far from other potatoes raised from tubers. Now, what happened? At the end of July some Royal ashleaf potatoes near the seedlings were attacked by the disease; and after a time—about a fortnight—it spread to the seedlings and attacked all, no matter what age—some with tubers large enough for cooking, others with potatoes about the size of a pea, and even some that were not long planted out, a few inches high, and destroyed them, before they had the chance of producing a single tuber. The disease also attacked some potatoes raised from tubers which had only been above the ground a few days. The larger seedlings held out manfully against the attack, and made a desperate attempt to throw off the disease; and at one time, if the weather had remained fine, they might have succeeded; but the smaller ones could not have recovered in any case. A few of the tubers were affected; but I saved as many as I required.

This experiment, then, appears to decide the question that at the end of the summer, in very damp weather favourable for the extension of the disease, potatoes may be attacked at any age. How is it, then, it may be asked, that the potato is not attacked at an early stage in spring, and completely destroyed? The reason is, that the fungus requires time for development. Although potatoes are sometimes planted with

the mycelium, or spawn of the fungus, in them, they would not always produce diseased shoots; so that there are comparatively few centres of infection, and it requires time for the disease to spread over large areas; besides, the fine bright days and cold nights which generally prevail in early summer are not favourable for the development or extension of the members of the fungoid family.

A gentleman from Cornwall wrote to me, after seeing a letter of mine in the *Times*, and said he thought the disease did not begin at a certain time of the year, as the letter seemed to indicate, but at a certain stage of the plant; because, whilst the potatoes were suffering from the disease in Cornwall, he noticed, in travelling up the Great Western Railway, that they were still green at various places on the line of railway. This difference really arose from the circumstance of the climate being earlier in Cornwall. The fungus requires time to grow and develop as well as the potato, and the potato being more forward there, the disease is also. In Gloucestershire and the Midland Counties it seldom appears extensively until the third week of July, and sometimes later; whilst it is earlier in Cornwall, and later in Cheshire, and still later in Scotland.

At the same time, I believe the potato is more likely to be attacked at a certain stage, and that is just after the tubers have commenced to form, as before remarked; and you frequently see the early potatoes attacked when the later ones in the same ground are still green. Sometimes they are attacked in the regular order of planting, particularly in a wet season like this; whilst at other times it is not so, and the disease first commences in some damp spot.

CHAPTER VIII.

Prevention and Mitigation of Losses by the Disease. Recommendations to the Small Grower.

In the previous chapters I have referred to the first appearance of the disease, and expressed my opinion as to the modernness of its origin, as far as we are concerned, and referred to the spread of it, showing that no part of the

United Kingdom finally escaped its ravages; and afterwards reviewed the many causes assigned to account for its origin, and then traced it back to its original home in America, and afterwards explained several of the phenomena attending its presence here, and gave a description of the fungus, and devoted a chapter to the disease in America, and the experimental farm at Vincennes, in France, and the time of year when it usually makes its appearance. And now the only task left before me is to make some suggestions for mitigating our losses by the disease, if not to extinguish it altogether. With regard to this I think I cannot do better than, in the first place, copy here a letter which I sent to the *Times* in September last.

SIR,—As I may perhaps be able to make some suggestions which will be of considerable service to the labourer in guarding himself from the serious losses from the disease which he has lately experienced, you may not object to afford me a little more of your valuable space for that purpose.

About twenty years ago, or more, the potato disease was a fashionable subject, and almost every writer had a theory of his own to account for its origin; but now, when sufficient time has elapsed and sufficient data accumulated to enable one to arrive at a satisfactory conclusion with regard to it, nearly all interest appears to have subsided, and the unfortunate potato is abandoned to its fate, and the disease allowed to do its worst without any further effort being made to arrest its progress. I take a considerable interest in it, and for several years past have been making experiments with the object of mitigating our losses by the disease. With regard to the nature and origin of the disease, the conclusions at which I have been able to arrive are satisfactory; but with regard to the remedial measures, I am sorry to say that I have not yet made all the progress I desire, although I have reduced my own losses considerably. I have in the present season tried the application of lime, sulphur, &c., to the plants, without much success. It is true that this has been a rather difficult season in one sense for the experiments; and that is, the substance was no sooner applied than it was washed off by the rains. But to return to the point, how can the labourer reduce his losses? The labourer should plant his potatoes as early in the season as the state of his land will permit, and if the soil is light put them in not less than five inches deep, and directly they appear above the ground slightly cover them with long litter to preserve them from the frost. It is the common custom here for the labourer to leave his potato planting until the evenings are sufficiently light for him to do so after his day's work

is over, so that it is very often nearly the end of April before he has finished. This is too late; he ought to get a day or two for the purpose and finish earlier. I began planting early in March and finished all by the end of the month. He ought to grow a good breadth of the Royal Ashleaf, American Early Rose, and Early Vermont. In many seasons the tops of these early potatoes would die off before any disease appeared, in which case they are perfectly safe; and although in others, such as the present, that would not be the case, the tubers, being in a sufficiently forward state for that purpose, might be dug up before much harm had been done by the disease. That was the case with some of the Early Rose and other potatoes I grew this year. Mine were put in early and produced well, eight pecks for one, with little loss by the disease; while a neighbour who planted the same kind of potato, but later, lost nearly half. I have observed the same result on other occasions. When the disease first makes its appearance in his neighbourhood the labourer ought to examine his potato crop from day to day, and directly he sees the leaves affected should dig a few roots to ascertain the state of his crop. If they are in a sufficiently forward state, so as to be worth digging, it should be done without delay, before the stems are seriously affected, and then the loss will be trifling. With regard to the later varieties, the labourer might grow the Red Skin Flourball and the Skerry Blue, and other robust-growing varieties which are not as much subject to injury as others. It is true the former is not of first-rate quality—but the labourer is not generally very fastidious in his tastes—and the Skerry Blue is rather deep in the eye, which is an objection, but may be avoided by boiling it before it is peeled, as is the custom in Ireland.

The wife of a Wiltshire landowner has been anticipated in her recommendation with regard to obtaining seed from the Continent. A few years ago a French gentleman recommended a potato in the *Agriculture Pratique* called the 'Pomme de Terre de Norvége,' or Norwegian potato, as being entirely free from the disease and not very liable to it. I wrote to him and found him very civil and obliging. He sent me some of his potatoes. I found his statement true; there was not a taint of disease among them. They were planted, and produced crops for two or three years without any disease whatever, but did not escape this season. They were attacked, but the loss was comparatively small; out of two sacks just dug, about one-tenth were touched. Unfortunately, this potato, like some others which have a disease-resisting power, is not of first-rate quality, or it would be invaluable. Such as it is, I intend to put a few into some labourers' hands; and, if they are satisfied with them, will take the necessary steps to bring them into cultivation.

F. BRAVENDER.

Cirencester, Sept. 8.

The day before this letter appeared in print the following was communicated by Mr. N. T. Everard:—

SIR,—The farmer of an inquiring turn of mind may fairly confess himself nonplused when he finds the highest authorities on farming subjects at such complete variance as the learned author of the 'Book of the Farm' and Major Hallett, the originator of the pedigree system.

I quote from section 3,034 of Henry Stephen's 'Book of the Farm':—

'A curious and important fact was discovered that diseased potatoes may be safely used for seed. Benjamin Smith, of Wokingham, Berkshire, planted very much diseased sets of ashleaved kidneys on March 18, in drills 5 inches deep, and the crop was taken up sound and ripe on August 2 without disease; while sound sets of ashleaved kidneys and others a mixed lot were planted in February as before, and on being taken up in August were found to be much diseased.'

Which course is the distracted farmer to follow? Is he to sow health or disease? To those who do not care to try tedious experiments I would venture to recommend a trial of freshly-imported seed. I have been in the habit of getting fresh seed of the Champion potato from Scotland each year; and now, while the air is almost everywhere tainted with the smell of rotting potatoes, I can point with satisfaction to a crop almost free from disease, though, in the same field, my more conservative tenant has hardly a sound tuber to show.

N. T. EVERARD.

With regard to these letters, I now propose to make a few remarks, and will refer to Mr. Everard's first. Whether diseased sets produce a sound crop or not depends on a variety of circumstances of which the presence of the mycelium of the fungus in the potato is only one. In the first place, the potato fungus is closely allied to the Saprolegnieæ, which flourish only in water, and are great lovers of moisture. If that is not present the fungus does not flourish. Again, a certain amount of warmth is required, and in the instance reported we have not all the facts before us. For instance, the letter does not say if those planted in February had shoots on them when planted; if not, although planted earlier they probably came up later. Again, was the soil the same, or was farmyard manure applied in both cases? If those which were affected were placed in a damp spot of ground, or in highly manured land, that might be quite sufficient to account for the presence of the disease in one case and not in the other.

Somebody once asked Charles I., 'How is it if you have a bowl of water, and then put a live fish in it, the bowl does not weigh any more than it did before?' 'Fetch me the bowl,' he said, 'and let us weigh it;' which was done, and then the fish added, but, lo! it was quite a mistake—the weight was decidedly greater. Now, with regard to the potatoes that were planted, were both lots perfectly sound and untainted? I very much doubt it. Seed tubers which are perfectly free from disease are a much rarer article than is generally supposed; and this year there are very few to be found in the country, from John o' Groats to Land's End. Our stock now is in a very bad state. Some people speak as though, after the first commencement of the disease, there has been a gradually increased contamination of our stock; but I do not think so. Like the tide, the condition ebbs and flows—one year very bad, the next year, perhaps, better. I would advise no one to plant unsound tubers, if sound ones are available. It would very much improve the crop of the small grower if he had a source from which sets could be procured entirely free from contamination; indeed, the same remark applies to all.

Now, with regard to the recommendations for the small grower contained in the letter, I have not very much to add. The remarks in the letter, although I do not say so, besides being the result of practical experience, are in accordance with our latest scientific knowledge. The labourer and small grower, generally, has but a limited space at command, so that he cannot crop just as he likes; but I would recommend him to change his potato land as often as he can where disease has prevailed. The Norwegian potatoes which escaped the disease so long were planted in a piece of ground where lucerne had been grown for several years; and it is possible they might have remained free in 1879, if they had been grown in the same place; but it was not convenient to do so. On digging up the crop, all decayed potatoes and haulm should be burnt or buried in a hole made in the ground where potatoes are not intended to be planted the following year; they ought not to be thrown on manure heaps. The labourer ought to grow more vegetables than he now does, particularly for winter use, such as Savoy cabbages, Brussels sprouts, and other greens; and, in order

to get them well forward, should plant them between every other row of potatoes, turning the tops of the potatoes together in the unplanted row; and why he does not plant a good supply of that delicious vegetable broccoli for spring use, I cannot understand. It is true it occupies the ground rather long, and sometimes it is too late for it to be succeeded by a crop of potatoes; but that difficulty may be got over in the following manner: Plant a piece of vacant ground, after early peas or some other early crop, in the first week of July, with the mammoth or some other hardy broccoli, three feet apart in the rows, or nearly; and in spring, before all the broccolis are cut, plant the intervening spaces with disease-resisting potatoes, and afterwards draw the old stems of the broccoli, and earth up well. I have done this, and found it answer very well; and, with strong-growing sorts of potato, the crop is just as good as though the other crop had not been grown. If these remarks should meet the eye of any clergymen or others interested in the welfare of their poorer parishioners, I think they would do them a great service by calling their attention to this and the remarks contained in the letter to the *Times* with respect to early planting, &c.

CHAPTER IX.

Disease-resisting Potatoes.

It is an undoubted fact that some varieties of the potato are much more liable to be attacked by the disease, and suffer more from it, than others. This was found to be the case soon after the first appearance of the disease, and several kinds of potato disappeared from cultivation altogether, and are now forgotten. The same thing is experienced at the present time. The old original Ashleaf is more delicate than the Royal, or Myatt's Ashleaf; and, although earlier than the

others, is little cultivated now, and in danger of going out of cultivation. The Snowflake, too, suffers a great deal; and it is unfortunate that the splendid potato, Paterson's Victoria, also suffers so much from the disease. I think this arises partly from the circumstance of all the tubers being produced so close to the stem without room for any intervening space of soil, so that one decayed tuber in a wet season tends to decay the others; and, therefore, a variety of a more spreading character would suffer less.

If we are to have many more wet seasons, there will be a danger of the two potatoes above mentioned disappearing from cultivation; but we must hope for better times.

In 1877, Mr. Jas. Bird Kennedy, who lives on the shore of Carn Lake, about seventeen miles from Killarney, had a field of twenty acres of self-sown Paterson's Victoria. The potato apples ripened so freely and well in 1876, that, after dropping off and remaining in the soil all the winter, they furnished seed enough to stock the field the following summer. What a splendid opportunity this gentleman had of securing a more spreading variety of this potato! but the desirability of this, most likely, did not occur to him. It would have probably required a good search to find new varieties; for, when the seed has not been crossed, the larger number of seedlings would very much resemble the parent plants, which is called by gardeners coming true from seed.

It is an interesting subject of inquiry as to what is the reason of this comparative immunity from the disease possessed by certain potatoes. I believe it arises principally from the mycelium of the fungus not being able to readily traverse the cell walls of the plant. The leaves even of the Magnum Bonum are generally affected; but only in exceptional cases does it extend to the tubers. Almost every potato grower must have been struck with the difference in the way in which even non-disease-resisting potatoes are differently affected under certain circumstances. Where heaps of strong manure have been carted to fields, and a rank growth promoted, the injury is often much greater in certain spots than in other parts of the field. The stems, too, of some of the disease-resisting sorts, are hard, and, I should think, not readily penetrated by the seeds of the fungus; but there is room for further investigation with regard to this. Until the past year

this branch of the subject never assumed the great importance it now does.

Although disease-resisting potatoes may be planted, the full advantage can only be obtained by care in their cultivation. I would recommend them to be planted a yard apart in the rows for field culture, and away from the earlier varieties, either in a field by themselves or at the other end of the same, with a wide interval; and at the time of raising, if a *single* diseased potato is found under a root, *all* the produce of that root should be put in a different basket from the rest, and not used for seed the following year. The best plan is to eat the doubtful produce. They, in all probability, have some of the mycelium of the fungus in them, but that would not be injurious to the consumer; cooked mycelium is as good as cooked potato, for aught I know, I have no doubt eaten a great deal of it. A Frenchman once made a martyr of himself by living entirely on diseased potatoes for three or four days (I believe he had them cooked), and no injurious consequences ensued, so that we need not fear to use those which are merely doubtful.

Potatoes may be divided into three classes with regard to their disease-resisting powers:—Magnum Bonum, Scotch Champion, and Norwegian, being in the first class; Royal Ashleaf, Myatt's Ashleaf, and Skerry Blue, and others, being in the second class; and the original Ashleaf, Lapstone, Snowflake, Paterson's Victoria, and a host of others being in the third class. There are some new candidates in the field for a first place in the above list, which I intend to grow this year. We do not possess, that I am aware of, a thoroughly good disease-resisting second early, and a small fortune awaits the fortunate individual who succeeds in raising an early Magnum Bonum; but the raiser ought to get a good stock in hand before he parts with any. The most likely way I know of securing the desired object would be by raising a very large number of seedlings from Magnum Bonum, without the aid of any cross. If one had the opportunity of looking over a field of self-sown Magnum Bonum, as in the case of the Paterson's Victoria before mentioned, I think what is required would be readily obtained.

There are several potatoes in cultivation which have, to a certain extent, disease-resisting qualities, such as Red-skinned

Flour Ball, Champion of Scotland, Norwegian, Magnum Bonum, and Skerry Blue. These are principally strong growers, of vigorous constitution, but some of them are not of very good quality. I have never tasted a Flour Ball that was fit to put on a gentleman's table, and I should think it does not meet with a ready sale; but with the labourer it is different. When cooked one day and fried the next it is not so bad; at all events, better than going without any, as many labourers must do this year. At the same time I think he would do well to introduce the Scotch Champion and Magnum Bonum to his list in cultivation, for they are undoubtedly superior.

A short time ago the Royal Agricultural Society offered some prizes for potatoes which were entirely disease-resisting. Several varieties were sent in for trial; but it was discovered, as was tolerably well known, that there were not any. Now, although such is the case, and at the present time we have none entirely free, there is no reason why some should not be *raised* from seed. Indeed, with care in cultivation, some of them so nearly approach the desired goal, that in a few more generations we might obtain what we desire. Mr. Darwin says, in 'Plants and Animals under Domestication:'—'Will a race horse ever be reared fleeter than Eclipse? Can our prize cattle and sheep be still further improved? Will a gooseberry ever weigh more than that produced by "London" in 1852? Will the beet-root in France yield a greater percentage in sugar? Will future varieties of wheat and other grain produce heavier crops than our present varieties?' These questions cannot be positively answered, but it is certain we ought to be cautious in answering in a negative. Now, with regard to the potato, comparatively little has been done, and there is a wide field open for further improvement, which has scarcely been so much as entered upon; but this labour ought not to fall on private individuals without assistance from the State. The Government ought to assist with a grant of money, and might, with advantage, offer the following prizes:—200*l.* for a potato entirely resisting the disease; 100*l.* for a Flour Ball of better quality; 100*l.* for an improved Norwegian; 100*l.* for an improved Champion of Scotland; 100*l.* for an improved Skerry Blue; 100*l.* for an earlier variety of Magnum Bonum.

The award of these prizes might be left to the decision of the Royal Horticultural Society, if they would undertake the management of the fund. If these prizes were offered, new and improved varieties of potato would soon be forthcoming, an advance on those now in cultivation, and render us almost independent of the disease. And, if, as I think can be done, some were obtained which could be grown entirely free, *this would be one way of preventing the potato disease.*

The following are successful instances of the growth of disease-resisting potatoes:—

THE CHAMPION POTATO.—A Farmer's Lesson.—A great deal has been written of late about the Champion potato in different periodicals, and no doubt, if the quality for eating is as good as its cropping qualities are, it will certainly take a leading place with all potato growers. In this neighbourhood its disease-resisting properties are evident. I will just state, for the benefit of those of your readers who may be interested in potato growing, what has been accomplished on a farm within a mile from where I live. The farmer, Mr. Greaves, who is considered to be a good cultivator of the soil generally, has a field of twelve acres of rather moderate quality, and was doubtful whether it would grow a crop of turnips. He also had doubts about its growing a profitable crop of Scotch Regent potatoes, as they were subject to disease on the land. At the last moment a spirited potato dealer turns up, and offers 10*l.* per acre for the whole twelve acres. Conditions were drawn up, and the offer accepted. The conditions were, that the farmer should prepare the land for planting; in fact, should find horse labour for putting the potatoes into the ground, clean and plough out the potatoes, and then cart them to the station, a distance of over two miles. This labour is likely to be a serious undertaking for Mr. Greaves and his horses. In addition to the labour, Mr. Greaves supplied ten cartloads of farmyard manure to the acre. The potato dealer supplied the following artificial manure: 6 cwt. of superphosphate, 2 cwt. of kainit, 15 cwt. of woollen manure to every acre. The potatoes were planted 4 ft. between row and row, and 18 inches between set and set was to be the distance in the rows. In this last the conditions were not strictly carried out, and 16 inches was nearer the mark. All the soil was used that could be got for earthing up, which made good-sized ridges for the potatoes to grow in. At first, from the coldness of the season, the potatoes grew badly, and fears were entertained about the crop. At last the fibres took possession of every particle of soil that had been moved in planting and earthing up. The land was soon covered, so that the rows were not perceivable, and the ridges were packed with potatoes in such a way as only Nature could pack them. I was

curious enough to go and see the crop ploughed out—and such a crop it was as I never saw in any field before: the sample was good, with a fine even lot, not too large, and few very small or set potatoes among them. Nearly half the field was taken up when I carefully took stock of them. I came to the conclusion that there were at least 10 tons to the acre; Mr. Greaves was a little under my estimate. 6*l.* per ton was refused when the crop was taken up; this would make every acre worth 60*l.* I hear that the potatoes are to be kept until they are worth 8*l.* per ton, which will make the crop worth 80*l.* per acre; this on land rented at, I believe, under 30*s.* per acre. Let me ask the farmers where they can find a better friend than the land they cultivate, if they treat it liberally and fairly. Our spirited potato dealer hopes to clear on to near 300*l.* by this one transaction. I wish he may; he deserves it, for the lesson he has taught the farmers here. I shall be curious to see the crop of wheat that follows this potato crop, and will report it to you. I think I can say with confidence that Mr. Greaves has learnt a good lesson, and when he has next to cart such an astonishing lot of potatoes to the station it will be for the benefit of his own pocket.—William Culverwell, Thorpe Perrow, North Yorkshire, in the *Gardener's Chronicle.*

This was surpassed by the following:—'Two years ago, Mr. J. Godden, of Woodstock, planted one sack of Magnum Bonum potato, which produced 12. Last year he planted 10 sacks, which produced 140. This year (1879) he has between six and seven acres, which are a good crop, again free from disease. These potatoes are worth more in the market than the above, and would purchase the land on which they grew.'

CHAPTER X.

Autumn Planting, and Cutting the Tops.

AUTUMN planting has been from time to time recommended as a good plan for the purpose of avoiding the disease; but, although many have tried it, few have continued the practice very long. The alleged advantage is that the potatoes are not weakened by having had the sprouts taken off, and that you get the advantage of the first shoots, and

also that they come up earlier. The first shoot is, no doubt, the strongest; and, to obtain that, I have heard of some growers who put the seed potatoes in boxes in cowsheds over the cows' heads, and obtain what they require in that way. The only land suitable for autumn planting must be very dry; and I have heard the following objections to the practice. The rooks sometimes find the potatoes, and scratch them up; and in forward seasons the early varieties start growing much too soon, and are liable to be cut off two or three times; and when that is the case they can never do much good. I do not think autumn planting a good plan in gardens, particularly after a wet season, like 1879. I should be afraid the sets would decay in the ground; and as some of the land which was in potatoes that season would probably be under the same crop again, I think it would be much better to turn up the ground roughly, and expose it to frost. And with regard to the seed tubers, they ought, for planting on a small scale, to be spread out singly on trays. The lids of the American cheese tubs, which are very cheap, and can be procured of any provision merchant, make excellent trays for that purpose. I generally imitate the poor people, and keep some of my choicest stock in my bedroom, where there is no danger from frost. If the temperature of the room is too low, the potatoes must be covered over, or removed to a cellar, where they will be safe. With regard to cutting the tops, a great diversity of opinion prevails. Some persons say they have done it with advantage; others not. I have tried it in my garden, and the conclusion I have come to is that it is not desirable to do so in a patch from which you are digging for daily consumption; the quality of the tuber is affected immediately, and it is not worth eating; and, as you are gradually reducing the quantity, the risk of loss is not much. But in cases where you have a patch of the original Ashleaf, or other delicate varieties, intended for seed, I think it may be done with advantage; but it must be done at the right time — *i.e.* before the stems are seriously affected. Examine the state of the crop; and if the tubers are sufficiently large for seed purposes, but not quite ripe enough for lifting, and the disease is just extending from the leaves to the stems, cut off the tops, or set a foot on each side and draw them out. Whether this plan is of advantage with regard to the general

crop depends upon the condition it is in at the time. The following is an account given by my neighbour, Chas. Lawrence, Esq., of the Querns, Cirencester, who is an experienced agriculturist, where the drawing out the tops was attended with success; but, for the future, when, as I believe, few except disease-resisting sorts will be grown, the cutting of the tops will be of less importance than hitherto.

My beds are thrown up in the autumn 12 ft. wide, leaving alleys between about 12 in. in width and depth. I never use any manure for this crop. The potatoes were planted entire, with few exceptions, in March, 2 ft. apart in the rows, which are 3 ft. apart, and 5 in. deep, to retard their too early appearance above ground in the spring. At the end of July, 1876, on a careful examination of the crop, I found the haulm and leaves in a green vigorous state, without the usual indications of disease on either. On inquiry amongst my neighbours, I received the same encouraging reports; indeed, such were the reports given in the *Gardener's Chronicle*, in the month of August, from Scotland and various English counties. About the middle of August occurred some heavy rains, after some very hot sunshine; and, the haulm still appearing green, I apprehended sprouting of the tubers under ground; and bearing in mind the success of an experiment on a small scale under similar circumstances, at a former period, of drawing off the haulm by the roots, I resolved on adopting that course throughout my entire crop. The potatoes were formed in point of size, but as yet unripe, the skin not being set firm. At that date I desired my gardener and his assistants would, placing one foot on each side of the plants, carefully draw the haulm by the roots, without disturbing the tubers. The last week in September, having found them thoroughly ripe, the potatoes were forked up on the surface to dry, and were then wheeled for storing. On a casual inspection, while lying on the surface, the crop appeared free from disease. The men were directed to examine carefully every potato before it was stored, and to set aside all in any respect unsound for my inspection. A piece of ground was set apart for this purpose (six feet wide), and the potatoes were placed on this in the shape of a cone, carried as high as they would remain, leaving a foot margin of the earth around it. The heap was lightly covered over for a week, preserving a free circulation of air through it. The outer soil was then thrown on the margin left, and over the heap about eight inches thick, thus leaving a hollow space all round to carry away any drippings from the thatched roof over all. My gardener sent in to me the unsound tubers which were found on storing the crop—four in number only, three of which had clearly been partially eaten, the remaining portion, when cut through, being

quite sound. I enjoyed the notion that I had at last secured a sound crop of this useful esculent, until I was alarmed on reading in the *Gardener's Chronicle* of October 28 as follows:—'The potato disease is reported to be very bad in the neighbourhood of Cirencester.' On inquiry I found such to be the result on digging crops which had appeared in as safe a state as my own at the beginning of August. Soon afterwards I saw a report of a case in which it was stated that on opening a store of potatoes (whether pitted or otherwise did not appear), quite free from disease apparently when stored, a large proportion was found diseased. It was not without some fears that I determined on uncovering my heap, and removing the contents into my cellars the last week in December. Being confined within at the time, I desired the men would measure the sound potatoes sent into the house, having carefully examined the store, and laid aside for my inspection every questionable tuber. The basket brought to me contained nineteen tubers only, making, with those four previously stated, twenty-three faulty tubers out of a crop which filled seventy-two bushels. A large proportion of the nineteen were partially eaten or bored; the remainder were not examined. This crop more than supplied my family in sound condition to the beginning of this month, when the young potatoes of the season were ripe for table.

Such is a mere statement of facts, on which your readers may rely. I may add the variety I have described is Paterson's Victoria, which I obtained from the late Mr. Paterson within a year or two after its introduction, now some fifteen or sixteen years ago. The perfection of this variety in my soil has induced me to rely on it solely up to the present time as my annual crop. I have gone very carefully over this year's crop from the last year's seed, and I could not find the brown spot on the leaves or stem of a single plant.

CHAPTER XI.

Directions for the Grower on a Large Scale.

THE directions for the grower on a small scale are only partly adapted for the grower on a large one. The large grower has an advantage in the extra space at his command for the growth of his crop, so that he need not often plant the same field with the same crop more than once in eight or ten years;

on the other hand, he has a great disadvantage in having to deal with a greatly increased bulk of produce, and the important question of storage comes into play, and this is rather a difficult one. In attempting to avoid Scylla he is apt to fall into Charybdis. If he raise his potatoes early when suffering from disease, and store them in a pit, they all may decay in the pit; on the other hand, if he leave them in the ground all may go there and not be worth the trouble of raising; and if you consult the authorities and refer to the Agricultural Society's *Journal*, where the opinions are given on this point by no less than 100 growers, some of whom plant 60 acres or more a year, you find the most contradictory opinions; 'quot homines tot sententiæ.' It certainly does seem to me strange there should be this difference of opinion amongst practical men; but these different views may perhaps be reconciled when we bear in mind that some of them grow their crop for the early market and others for selling late, and that the difference of seasons and state of the crop leave room for the exercise of judgment on the part of the cultivator. I have no occasion to refer to these authorities for my own guidance; I satisfied myself long ago from experiments in the garden that it answered the purpose best to harvest the crop early, but a few extracts may be interesting.

Mr. Scot Skirving remarks:—'Disease has never struck the early varieties in East Lothian so hard as the late ones. Those ripe in July and August comparatively escape. Therefore if the potato will keep, the sooner it is harvested the better in disease years. In 1872 I realised 15*l.* per imperial acre, while many of my neighbours made a dead loss. I lifted *and sent to market* in August. I could not lift them fast enough, and lost much more the longer I was in lifting. Had I been able to lift faster I should have made 20*l.* per acre.' I entirely agree with this gentleman, and those who have followed this plan with the early varieties have made the most money of late years.

Mr. S. D. Sherriff says:—'We have had many instances of *total* failure, but this was owing to the crop being attempted on soils totally unsuited to it. I may mention that I in 1872 sold my crop of 60 acres for 1,200*l.*, and the purchaser gave me 800*l.* and never touched the crop. I sold the crop on August 5. The disease had appeared with great virulence in

the stems and in 3 acres of early ones in the tubers. Three-fourths of the crop were lost.' What a tremendous loss on one crop! I feel sorry for the man who lost his money, but he was not sufficiently careful. He ought not to have purchased the potatoes, seeing the disease at work, unless there was a paying crop beneath the ground, and then should have commenced raising them at once.

Mr. J. W. Robinson, of Wyberton, Boston, says :—'In some instances I have found it better to harvest late, as those potatoes which are attacked early then return to mother earth, and leave only the sound ones to be picked up. In other seasons (say very wet ones) the opposite effect might be produced; the diseased ones would rot the few sound ones even in the ground. There are no two circumstances exactly alike; what is right in one case may be perfectly wrong in another.' The opposite effect has indeed been produced the last two seasons; the potatoes have decayed terribly in the ground. There may be something in what this gentleman says about all decaying that are likely to decay in a dry season, and the rest may be sound, but I cannot recommend that plan; it is departing from any definite principle of working. How is the farmer to know what the weather is likely to be in the autumn? He would be apt to think the weather would be sure to improve when it might not, and thus be led into a false position, and the favourable opportunity gone; whereas if he were always on the look out to harvest as early as possible, he would be sure to be right, but he must not mind the trouble of sorting over his crop as often as is necessary. I would much prefer to go to the expense of carting the potatoes to a barn or other building, and not pit them until November, sooner than run so much risk of losing the crop; at the same time it must be admitted that there will not be so much risk of loss in the future when, as I anticipate, disease-resisting varieties will be generally grown.

I ought, perhaps, here to say a few words with regard to the cultivation of the potato, at all events so far as particular modes of cultivation affect the soundness of the crop.

Potatoes may, I think, be introduced with advantage by many farmers as part of their ordinary rotation of crops. To the ordinary course of turnips, barley, seeds, and wheat, potatoes and oats may be added. They would afford other

crops which ought to be made pay for cultivation, and prevent wheat and clover occurring so frequently in the course; but the price of potatoes cannot be expected to keep up at what it is now, and an effort should be made to meet the reduction by improved means of cultivation.

The mode of cultivating potatoes on their first introduction was either by the dibble or spade on the flat or in lazy beds; but when field planting increased, these methods were found to be too tardy and expensive on large arable farms when hand labour was scarce; and hence originated the system of cultivating in drills, either by means of the common or double mould plough. This system has been general for 70 years in Scotland and England, but in Ireland it is of more recent introduction. On the light turnip soils of Scotland, a decided improvement was made by the newer method of ploughing in the seed and manure every third furrow according to Mr. Haxton, and has had the effect of improving not merely the quality, but also the quantity of the produce. The following is a good method of cultivating potatoes in raised drills, recommended by Mr. Haxton. The land (a corn stubble) is ploughed with as deep a furrow as possible in the early part of the winter, and, as early in spring, as the state of the land will permit of it, is cross ploughed to the full depth of the stubble furrow. After a few days' exposure to drought, the land is harrowed down, and, if necessary, also dragged thoroughly with a grubber; but, if clean, the last operation is unnecessary. The land being worked, as before stated, and ready for being planted, is first laid off in five or six yard ridges, or stetches, by slightly marking it with a plough. Along each of these furrow markings the dung is laid on in heaps of ten or twelve to each cart, and distant from each other some five or six yards. The double-mould plough is then set to work on the further side of the field, and as soon as one drill is formed, four women commence to deposit the seed in the bottom of the newly-formed drill; and other four women, having an equal number of heaps allotted to each, commence to carry forward the manure and spread it above the seed. As soon as six drills are thus formed, planted, and manured, another plough commences to cover all in by splitting the drills, or, if the field is in any degree steep, the two ploughs may be made to work round and round, and

after each other, opening new drills when going one way, and closing those that are planted and manured in returning. After both ploughs are started to work after each other, it is not necessary to have more than four drills exposed to the sun and air after being planted, as the spreaders and planters are all working on the outside drill, and the ploughs cannot come in contact, as they are always following each other, and never can be nearer when passing each other than the breadth of four drills, which, at 27 inches, makes 3 yards. When the field is finished, it presents precisely the same appearance outwardly as in the former case, but the interior of the drills is different, the seed being under the manure, and the land not consolidated by the weight of the carts. Those who prefer having the seed above the manure (which the writer prefers) can easily effect this by spreading the manure first, and placing the seed afterwards; the only precaution necessary being to make the horse on whose side the open drill is, walk on the top of it so as not to touch or displace the sets with his feet. When the seed has sprouted and about half way to the surface, the drills should be well harrowed by the bent harrows which are made so as to scarify every portion of them, and thoroughly to break the outside crust. In the course of a week or ten days the young plants will begin to show above ground, and as soon as all are up the intervals between are thoroughly stirred with the drill grubbers, and the plants themselves are hoed round about by means of the hand hoe. In another week or ten days, the plants receive a slight earthing up, and are then left to grow until they are pretty well forward, and about half way to the middle of the drill, when they are again grubbed between the rows, but not so close to the plants as at first, then hand hoed lightly, and picked free from surface weeds, after which a final earthing up is given as deeply as the horses can go through with the plough. Some farmers dispense with this second earthing up, and prefer delaying the first earthing up to a later period, and then making one good earthing up do for all; but, in deep soils, not too hilly, two earthings are always to be preferred, whether as regards the decided benefit derived by the plants, or the cleaner condition in which the land is left in autumn.

This method of cultivation, although so generally followed,

appears to me to be open to several objections. In the first place the land sometimes is not clean, and there is a difficulty in getting it so, and there is a great deal of work left to be done in the winter and spring, and interruptions may occur from frost and snow, and the final operation of planting delayed much later than it ought to be, and a great deal of the work has to be done at planting time, perhaps in March or April, just at a busy time when the farmer wants to be barley planting and other things; whereas if the land is ready, and the potatoes are planted with a pin, the operation can be performed at almost any time, and might be done by the women on the farm under the farmer's supervision. Besides, there is another objection, and that is the application of the farmyard manure at the time of planting tends to encourage the disease. If the stubble is clean, so that the land can be got ready before Christmas, there may not be so much objection.

The following is the method of cultivation practised by Mr. Myatt, of Evesham. He sometimes plants after broccoli or savoy cabbages, when no preparation of the land is necessary previous to getting on the manure, which he gets on in the autumn, say before Christmas. If, after wheat or other corn crops, he has the land scuffled or broad-shared, then harrowed well with heavy drag rollers or iron harrows, to bring the stubble to the top; and, if much, burns the longest of it, and then has it ready to get the manure on in the autumn. He generally uses from fifteen to twenty loads of good farmyard manure per acre; with the smaller quantity he generally uses from 2 to 3 cwts. of guano with marked effect, sown on the row previous to covering or filling in the holes after planting. If he can get town manure, he prefers it. Let it be drawn together, and then turned and mixed well together, a month before getting it on. Highly concentrated manures he found injurious, promoting a too rapid growth, which caused the potatoes to be more susceptible of taking the disease. The phosphates are much better; they promote a strong robust growth; by that he meant stout, short-jointed, not too rank. Mr. Myatt generally begins planting about February 12 to 14 with the early kinds, and later on into March for the others. He uses a large potato dibble or pin for planting; a man making the holes down every second

or third furrow, according to the sort, a boy to follow and drop a set into every hole; they then with a hoe fill in the holes, and the work is complete. He then leaves the land in that state until the potatoes come up, which is generally about the middle of April. He then, with a horse and a set of light iron harrows, has them harrowed across the furrow, which brings the land down to a fine tilth, levels it, and kills the young seed weeds which have then vegetated. In about ten or twelve days they are well up in full row. He then sends a horse with a small scuffle. He uses Busbey's, set about 15 or 16 inches wide, and 3 or 4 inches deep, up the middle, or between the rows, which breaks the furrow well at bottom; the men follow next day, and side-hoe them, and clear the rows of any weeds there may be left in them. In three or four days, or, if cold weather, perhaps a week, they will be about 4 inches high. He then follows with the earthing plough set 2 or 3 inches deep down the centre of each row, *i.e.* between each row, which will raise the earth to nearly 4 inches high from the bottom, and the work is complete. Mr. Knowles, of East Plain, Lancashire, who is also a successful potato grower, does not follow the same plan as Mr. Myatt. He adopts no regular system of rotation, but generally has potatoes to follow turnips, his object being to get the potatoes in early. Immediately after the removal of the previous crop, he ploughs as deeply as possible, and leaves the land in a rough state through the winter. He generally uses about 20 tons of farmyard manure, and 5 or 6 cwts. of phosphate to the acre, at the time of planting the potatoes. He gets all the varieties in as early as possible, and, in order to do this, he plants on land that has been green crop the previous year. He plants nothing but large potatoes, and in most cases cuts them in two, and plants 36 inches apart, and from 12 to 14 inches between the sets. This is in order to have plenty of room to cover them up when disease shows itself. He plants the sets as near the surface as possible (above the manure), cultivates as deeply as possible between the rows until the final moulding up comes. In the first place, he only partly moulds them up, then he takes the mouldboard off the ordinary plough, and puts this plough between the rows as deeply as he can to assist the drainage and loosen the soil. It lies in this state a short time, after

which, with the double-mouldboard plough, he adds a little more to the potato rows. Planting near the surface, and the frequent deepening between the rows, are, in his opinion, the principal reasons why he has so little disease on his farm. Another reason is, that when the disease shows itself, he moulds up until the foliage is almost covered, bringing the ridge to as sharp a point as possible to throw off the water, which prevents the rain carrying the disease with it to the tubers.

The method of cultivation of these two gentlemen differs from that which is generally followed. The great majority of cultivators on a large scale put potatoes to follow white straw crops and some of them to follow after clover which has been down one or two years, and a few after flax, beans, turnips, or mangolds. It is an extraordinary fact that Mr. Myatt and Mr. Knowles have suffered much less loss from the disease than many other cultivators, and the question naturally arises as to what is the reason. Early planting, I think, has a great deal to do with it. Mr. Myatt, in the Vale of Evesham, besides a good soil, has an advantage in climate; and Mr. Knowles, being near the sea, the same remark may partly apply. It would be very risky work in many parts of England to plant in February, and have the potatoes up in April. They would be cut off to a certainty, and if they had shoots on them would be hardly safe till the end of March. Both gentlemen plant the potatoes a good width apart—3 feet or more for some late varieties. That is, no doubt, an advantage with regard to preventing disease; there are more air and light for the plants, and room to cultivate deeply between them. Mr. Knowles plants only 3 inches deep; whilst I, in my garden, also Mr. Chas. Lawrence in his field cultivation, prefer 5 inches. The difference of soil and climate causes this. The practice, which is good in the neighbourhood of the Cotswold Hills, with a cold spring and light soil, is not so for heavier land in a wetter district. At the first glance one would think that it cannot be a good plan to plant potatoes after turnips, when they have been fed off, and perhaps corn given to the sheep, and the soil thus rendered rather rank, and then 20 tons of manure to the acre added; but on looking carefully at Mr. Knowles's observations, it will be seen that the turnips are not fed off, but removed from the land, and the land

ploughed before Christmas. All the objection thus vanishes, and Mr. Knowles is placed in about the same position as Mr. Myatt after his savoy cabbages are removed. His land, then, is in a thoroughly clean and workable state, and better results may be produced than in planting after a corn crop.

Short Summary of Recommendations.

1. Secure good seed, if you can, entirely free from disease.
2. Plant early.
3. On light land plant 5 inches deep.
4. On heavy land plant 3 inches deep, and earth up well.
5. Have the rows from 2 feet 8 inches to 3 feet apart in gardens, and 3 feet or more in the field for late varieties; may be rather less for others.
6. If danger of frost, cover along the rows with short litter, about enough to hide the plants from view.
7. Plant, if possible, in land not occupied by the same crop the previous year; and plant the late kinds, if possible, in a field by themselves.
8. Use medium size sets, or cut sets if large, about 12 to 18 inches apart in the row, according to size. If sets very small, need not be so far apart.
9. Manure in autumn, and use potash salts or bone phosphate in the spring; or else make a compost of manure and earth, ashes, &c.
10. Earth up twice.
11. Plant Royal Ashleaf, Myatt's Ashleaf, Magnum Bonum, and Scotch Champion, with occasional change of seed. Early Rose, Snowflake, and others may be grown, but should be watched and harvested early if in danger of disease.
12. Tops may be cut off those required for seed if tubers large enough.
13. Harvest late kinds sooner than usually done.
14. If any disease amongst crop, sorting over will be required.
15. If you have the convenience, store your crop for a time, and not put in pits till November.
16. On harvesting the crop, separate diseased from the healthy, as recommended in chapter on Disease-resisting Potatoes.

CHAPTER XII.

Stamping out the Disease.

THE question now arises whether it would not be possible to stamp out the disease by separating the healthy tubers from the unhealthy, in the same way that we endeavour to stamp out the contagious diseases of cattle. The disease had not been long introduced into this country before the general stock of tubers became very much contaminated, and has remained so, more or less, ever since. We must now retrace our steps, and improve them; also endeavour to close all the avenues by which the disease is capable of being spread. There are three ways by which the disease is capable of extending itself: 1. By the mycelium, or spawn of the fungus, being present in the potatoes when planted. 2. By the conidia, or summer seeds of the fungus, which are blown about by the winds, and are the principal cause of the rapid spread of the disease in summer. 3. By the resting spores or winter seeds of the fungus. Now, to avoid cause No. 1 it is desirable to secure as pure a stock of seed as you can; and this ought to be the first consideration, instead of the last, which it generally is. It would be better to dig up early those potatoes which are required for seed (which in some instances can be done before any disease appears), or most likely you will plant potatoes with the spawn of the fungus in them, and by so doing introduce disease to your crop earlier in the season than you would otherwise have it, besides being the means of extending it to others. I believe this cause of the appearance of the disease has hitherto been too much overlooked, as I have already pointed out, and that it will account for several of the phenomena with regard to the disease which have been so puzzling, as in the case of Mr. George Ville and the experimental farm at Vincennes, France, before mentioned. The idea naturally occurs whether this cause might not be more readily avoided by steeping the

potatoes in a solution of vitriol, carbolic acid, or other chemical substance, in the same way that the seed of wheat is treated for preventing the disease called the smut, and thus destroy the diseased germs. This has not been overlooked. I tried an experiment or two last year with negative results; but further investigation is required, and the expense ought not to be thrown on a private individual. The following was recommended some years ago as a suitable composition for steeping the seed tubers: 54 lbs. of lime, ¼ lb. of sulphate of copper, 7 lbs. of salt, and 25 gallons of water. Potatoes not to be eaten, but for planting only.

Supposing this steeping mixture, or some other, were successful, and it were generally applied, it would at once lop off one half the losses suffered from the disease by those who grow show and other delicate varieties of the tuber for exhibition.

To avoid cause No. 3 it is advisable to plant the potatoes in land which was not occupied by the same sort of crop the previous year or two, so as to avoid the resting spores of the fungus. Cause No. 2 is the most difficult to avoid. The conidia are produced in enormous quantities, and blown about by every wind—in fact, are the principal means of the spread of the disease in summer. A dry season may occur, not favourable for the growth of the conidia; but in a wet one, as in 1877 and 1879, they cause the disease to spread with amazing rapidity. The Colorado potato beetle was about twenty years in reaching the American coast from the interior of the country—that is to say, it travelled, or rather spread, at the rate of fifty miles per year; but the potato fungus advanced with much greater rapidity; and I think, in this country, it was capable of extending at least 300 or 400 miles in a single season. Persons who have taken all necessary care to avoid causes Nos. 1 and 3 may fall victims to No. 2 at the end of the season; but, although a person who is careful in planting sound tubers in his own ground may eventually suffer from the carelessness of his neighbour, still he would be repaid in his own individual case by the longer immunity from its attacks. At the same time, the larger the number of cultivators who attend to this and carry it out, the greater will be the immunity from the disease in the country generally.

Theoretical Plan for the Extinction of the Disease.

Another important question now arises, Would it be possible to extinguish the disease altogether? I think it would; but there are practical difficulties in the way in a country like England. It would be necessary to regulate the growth of the potato by Act of Parliament, and in various ways interfere with the cultivator of the potato in the management of his business, and could only be brought about on the score of urgent necessity; but at the same time, although it may not be at present practicable in this country, it may be well to refer to the way by which it might be accomplished; for no doubt the idea will be taken up elsewhere, where there are smaller islands and a less crowded population. The first thing to ascertain is, how long the resting spores or winter seeds of the fungus live—*i.e.* are capable of living. Professor de Bary thought it possible they might all germinate the same season they were produced, and not live through the winter at all. If that were so, the extinction of the disease would be easy; but I am afraid that would be too good news to be true, and that they live in the ground through the winter. Then it becomes a question whether they could live more than one year. I will suppose that they do live through the winter, and that they only survive one season. In this case it would be only necessary to discontinue the growth of the potato for one season, and destroy all chance growths, and then start with a pure stock of seed, and we should be free. This point might be readily ascertained in the following manner: Let the Government take possession of certain islands, such as the Isle of Wight and the Isle of Man, and pass an Act of Parliament requiring the inhabitants to refrain from planting any potatoes for one year (they might be supplied by importation with those that were necessary for consumption), and, in the following season, might be supplied by the Government with a pure stock of seed raised on frames. I have, on many occasions, raised potatoes on a hotbed in spring, and never observed any disease amongst the produce. The disease has, I believe, occasionally occurred under such circumstances; but it would be at once observed, if such were the case, and those discarded which were unsound. But a

safer, and perhaps more preferable, plan would be to raise new varieties from seed, which can be done in the following manner: Mix the seed with dry earth, and sow thinly, in the middle of April, in rows a foot apart, in good garden ground. One perch of ground will plant an acre. Transplant the seedlings to a field at the end of May or beginning of June. This should be done when they are four or five inches high. It is also necessary that each plant should have at least three square feet to grow in, as they develop a much larger root system than those which are grown from tubers. Another plan is described in the Appendix.

The above experiment may be carried out in dozens of small islands surrounding our coasts, some of which are in the hands of private individuals who can arrange things in their own way without consulting anybody or the Government. With regard to the distance from the mainland, which would render the crop safe there after a fresh start had been obtained, there is not very much data to guide one, but I should prefer half a mile or more of intervening sea. The detached portion of the Isle of Man escaped the disease for a time, and might have done so for a long period if the men at the lighthouses had not introduced seed potatoes from the mainland.

We will now suppose that certain islands have been fixed upon—say, the Isle of Wight and the Isle of Man—and that the proposed arrangements have been carried out; an Act of Parliament passed; and no potatoes grown in these islands for one year (the inhabitants being supplied by imported potatoes, sold to them by the Government at a cheap rate), and in the following year potatoes raised from seed only in the manner before described. If these were entirely free from disease, and their produce remained so, it would be safe to conclude that the resting spores of the fungus only lived one season. The extinction of the disease would then be easy. The same process might be extended to Jersey and Guernsey and the Azores, and would be a great boon to Ireland, and might be, finally, extended to the rest of the United Kingdom; but, to preserve the continuance of the immunity from disease, the importation of foreign potatoes would have to be forbidden.

Concluding Remarks.

The reduction of our losses by the disease is a very important question for us. The consumption of potatoes in this country is very large; and they are a crop which, with proper attention in avoiding disease, can be grown here better than in many other countries, and form a very important part of the food of the people. If we reckon the population at thirty millions, and reckon that each individual eats, on an average, a sack of three bushels per annum — which is a moderate estimate—and calculate the difference of price which has to be paid by the consumer in consequence of the losses by the disease at 4*s.* 6*d.* per sack, retail price—which, I think is a moderate estimate—this would amount to 6,750,000*l.* per annum, or approaching in magnitude the losses entailed upon us by the diseases of cattle.* But this does not represent the whole of the loss; for the farmer is, to a certain extent, restricted in the growth of the crop from fear of disease; and, when we import potatoes, the money which would otherwise remain in this country is lost to us. With the knowledge we at present possess, and without any further discovery, and without any aid from the State, nearly the whole of this loss may be prevented for the future by growing disease-resisting potatoes, and in other respects following the recommendations contained in these pages. Surely it is worth some effort on the part of the grower to bring his cultivation up to the required standard.

I hereby wish to express my ackowledgments to Professor Farlow, of Cambridge College, Massachusetts, for kindly furnishing me with information with regard to the disease in the United States.

* Mr. Thomas S. Scott reckons our losses for 1879 at no less than 15,000,000*l.*

APPENDICES.

I. The Dry Rot of Martius.

In considering the question whether the disease appeared in this country before 1845, it is desirable to refer to a previous fungoid disease which prevailed extensively in Germany in 1840, and, to a small extent, in this country, viz. the dry rot, which is thus described by Dr. Martius:—'The disease made its appearance after the tubers were stored in the pit or cellar, and when in early summer the sets were committed to the ground. In the latter case they perished before they had thrown out any shoots, or produced merely one or two minute tubers, which either did not produce shoots at all, or only such as were extremely weak and soon perished. If there was little moisture the tubers became hard and dry; and, as soon as the soil became wet, the greater part perished, so that the fields appeared like fallow fields sprinkled with a few stray potatoes of the last year's crop. The disease is often accompanied by scab, which, however, is not so universally diffused through the infected districts as the dry rot, but is sporadic in its appearance, while the dry rot is a complete epidemic. It was first observed in 1830; but it had increased in various parts of Germany to such an extent as to cause very serious alarm, and even to threaten the total extinction, for a time, of the cultivation of the potato. The potato pits, when opened, exhibited a greater or less degree of corruption, three parts out of four occasionally having become altogether useless; and of the residue, when planted, the greater part of them failed entirely. In the early stages of the disease, the use of the tubers was not found to be injurious to man or cattle; in the latter stages of growth, however, the decay is such as to make it quite impossible to use them.' This disease prevailed in England to a mild extent; and several of the writers, who thought that the *Peronospora infestans* had prevailed with them for several years before 1845, by their descriptions of the malady, had evidently been deceived.

II. Growing Potatoes from the Seed Apple.

It has generally been supposed that it required three years to obtain a crop of potatoes from seed; but the reason has been that the young plants, when transplated, have not been separated far enough from each other. The following plan, which is perhaps the best, is the one followed some years ago by Count Arnim's gardener, in Germany. The berries of the potato are collected in autumn, and are squeezed with the hand into a pot or other vessel, in which they should remain six or eight days to decompose, by which process the pulpy parts separate from the seeds; the seeds are afterwards washed well with water, and treated in the same manner as the seeds of cucumber. They are then dried, and kept in a warm and dry place. At the end of March, or beginning of April, the seeds are sown in a hotbed, and are treated generally in the same manner as early peas. The young plants should be protected from the frost, to which they are exposed at the season of the year in which they are planted. In the month of May the plants are transplanted to their permanent quarters. One of his most successful crops was planted on April 11, and transplanted on May 26. The plants at the digging time yielded largely, and one plant gave 280 tubers.

Expense of Cultivating an Acre of Potatoes.

	£	s.	d.
Trench ploughing the land with three horses and one man	1	0	0
Cross ploughing in spring, two horses and one man	0	11	0
Harrowing six times, or three double strokes	0	6	0
Rolling once	0	1	3
Picking weeds	0	1	0
Drilling twice with double-mould plough	0	10	0
Manure, say 12 tons at 5s.	3	0	0
Filling, carting, and laying down manure, 1s. 6d. per ton	0	18	0
Spreading manure	0	1	6
Planting potatoes	0	1	0
Seed, 8 cwt. at 6s.	2	8	0
Harrowing drills with semicircular harrows	0	1	4
Grubbing between the rows of plants	0	2	6
Carried forward	9	1	7

	£	s.	d.
Brought forward	9	1	7
First hand-hoeing, four women at 1*s.* . . .	0	4	0
Lightly earthing up with one horse	0	2	6
Second grubbing between rows with two horses . .	0	5	0
Second hand-hoeing and hand-weeding . . .	0	5	6
Last earthing up with two horses	0	5	0
Lifting potatoes, say 6 tons per acre; ploughing up, 5*s.* 4*d.*; picking up potatoes behind plough, 6*d.*; gathering potatoes in drills and after harrows; seven women at 2*s.* 4*d.* is 16*s.* 4*d.*; twice harrowing, 2*s.* 2*d.*	1	4	4
Carting, one single cart to every seven women gathering	0	10	0
Laying in pits and covering with earth . . .	0	3	0
Dressing and marketing 5 tons of potatoes at 5*s.*	1	5	0
Total expense of cultivation . .	13	5	11
Add rent	2	0	0
	15	5	11
Value of Produce.			
5 tons of potatoes at 5*l.*	25	0	0
1 do. small at 50*s.*	2	10	0
	27	10	0
Deduct cost	15	5	11
Profit, &c.	12	4	1

N.B.—The expense is increased by cleaning the land after wheat, and the profit is liable to be reduced by disease.

III. COPY OF REPORT OF THE ENGLISH COMMISSIONERS APPOINTED BY GOVERNMENT TO INQUIRE INTO THE CAUSE OF THE DISEASE, ETC.

MY LORD,—Having laid before your Excellency our views as to the best means of storing the potato and converting to useful purposes such as are too much diseased to offer a probability of being preserved, we now have the honour to bring under your consideration the question of seed for a future year. If, in our former reports, we have found it difficult to determine what course, under the peculiar circumstances of Ireland, it might be most advisable to pursue, we are still more embarrassed on the present occasion, in consequence of the conflicting testimony that has been presented to us, and the absence of all decisive evidence, as to the cause of the potato disease. The want of experience, derived from previous visitations of the same nature, also renders it impossible to affirm in what manner the potato may be affected in the course of the next few months.

We have, however, endeavoured to ascertain all that is positively known upon these subjects; by the examination of a great variety of published documents both foreign and domestic; by personal observation, and by inquiries directed to persons of practical experience or scientific reputation.

It is a very general opinion, and one entertained by men whose extensive knowledge entitles it to respect, that parasitical fungi, similar in their nature to those which produce mildew and dry rot, are the real cause of the malady. It is stated that one of these plants belonging to the genus Botrytis, and similar to that which some years since produced great mischief among the silkworms of France and Italy, has attacked the potato crop. It is described as entering the potato plant by the breathing-pores of its leaves, and then passing down through the interior of the stem into the tubers, in which its spawn or mycelium fixes itself, traversing the cellular mass, separating the cells themselves, causing alteration in their chemical condition, and thus spreading decay. In other cases, where the spawn is not apparently distinguishable in the diseased portions of potatoes even by the most practised observers, it is suggested that the juices of the plant may be vitiated by the parasite which destroyed the leaves, and that particles of it, too obscure to be distinguished by the eye, may be circulating with the juices, and producing disease by irritation. The presence of the parasite is not to be detected by the naked eye, unless it makes its appearance on the outside of the potato in the form of mouldy tufts; but its spawn may be detected in the diseased portions by the microscope, whether any external indications of its presence can be perceived or not; hence it is inferred that it is produced exclusively from within. It is, however, within our knowledge that, when apparently sound, potatoes are pitted in places where the mouldiness of a diseased potato is able to appear; that mouldiness rapidly establishes itself on the sound potatoes at every point where the surface has been wounded or bruised; and that, under such circumstances, the disease is immediately extended through the entire mass.

That the spawn of the fungi is present in large quantity in diseased potatoes is undoubted; the evidence of the best microscopical observers would be with us conclusive on that point, even if we had not verified the fact by personal examination. We also regard it as well ascertained that these parasites spread rapidly in warm and damp situations, producing infinite mischief under such circumstances; and that their advance is only to be successfully resisted by dryness. But it does not appear to us that their being the original cause of the disease has been well established. If it were so, it is difficult to conceive why fields of potatoes, placed very near each other, should be differently affected; or why certain varieties of this plant should be much more injured than others—the Irish apple potato, for example,

which appears to have suffered more extensively than any other. We are unable to reconcile with the theory of the potato disease being caused by parasitical fungi the remarkable fact that in its present form it is certainly of a modern origin. That it may have always existed is possible, though of this we have no proof; but at least there can be no doubt that it has only manifested itself to any degree within the last few years.

We cannot suppose the Botrytis, which observers find to be the kind of fungus that attacks the potato, to be a recent creation. We must assume it to have been coexistent with the potato itself; and, therefore, we must conclude that some recent causes have come into operation favourable to its increase to the present alarming degree.

Without pretending to decide what that cause really was, we may state that it seems to be connected with the cold, cloudy, ungenial weather which has characterised the present year over the North of Europe; conditions highly unsuited to the constitution of a plant which, like the potato, is a native of a warm, dry, sunny country, and insufficient for the ripening of the tubers. Without adverting to solitary cases, which require to be examined with more care than we have the means of giving to them, we may state that amidst the mass of conflicting evidence which we have obtained, the following facts appear to be established: —

1. That potatoes planted early in the season are more healthy than those planted later.

2. That the crop has suffered less in dry, elevated, sandy districts, where the influence of the season was mitigated by the slowness of the growth, or compensated for by the natural warmth of the soil.

3. That the late varieties of potatoes are more diseased than the early ones.

4. That the present disease seems to be confined to the northern parts of Europe and North America, and to be unknown in the countries to the southward.

If we are right in the conclusion at which we have thus arrived, there will not be cause for serious alarm as to the crop of another year, unless an equally unfavourable season should be experienced, or the supply of healthy seed should be insufficient, or that the parasite should be found to have so entirely taken possession of this year's plants as to overcome the natural power of living bodies to repel the attacks of such enemies to healthy vegetation.

It has been ascertained by actual experiment that potatoes, though diseased, will grow and produce apparently healthy plants. The Rev. Mr. J. Berkeley—a gentleman eminent above all other naturalists of the United Kingdom in his knowledge of the habits of fungi, and whom we have consulted on this occasion—states that though there certainly would be some risk of raising a diseased progeny from a

diseased stock, yet the growth of fungi so evidently depends on atmospheric conditions, that it does not follow that because germs are present they should be developed.

The above extract, down to the conclusion 1, 2, 3, &c., is a verbatim copy of the Report, which comprises about half of it. The remaining paragraphs are selected from the rest of the Report as being the only parts necessary to reproduce here, some of the Report being taken up about autumn planting, &c., and varieties of potato subject to disease more than others, &c., which need not be referred to.

This Report was signed by Mr. Robert Kane, Mr. John Lindley, and Dr. Lyon Playfair, and brought together a great many most important facts and suggestions with regard to the disease.

In offering the following remarks, it must not be supposed that it is with any idea of criticising what was written thirty years ago, but merely as comparing the conclusions with the additional information since obtained.

It did not appear to the Commissioners that fungi, being the original cause of the disease, had been well established, because certain fields of potatoes p aced very near each other were differently affected, or why certain varieties of this plant should be much more injured than others. They were also unable to reconcile with the theory of the potato disease being caused by parasitical fungi the remarkable fact that in its present form it is certainly of modern origin.

Modern facts and further experience have shown that this view of the case in reality presents no difficulty. Certain varieties of the Hop are more liable to the mould than others; and the Oiidium Tuckeri more readily attacks certain varieties of the vine, and fields planted with potatoes in a diseased condition would be liable to be attacked sooner than others; and, with regard to the modernness of its origin, the Oiidium Tuckeri began its attack on the vine the very same year, and that is now admitted to have been of American origin.

IV. M. Birot on Potatoes (translated from the 'Agriculture Pratique').

Amongst plants for consumptive purposes, the potato, without doubt, holds the first rank—the uses of which are so multifarious, whether for eating, the purposes of industry, or for feeding cattle; so that we

ought to seriously give our attention to its culture, to the manure to be applied, and to the varieties the most productive and the most resistant to the disease.

This year we have cultivated in the experimental field of M. Alfred Duduoy, at St. Ouen-l'Aumone, about eighty varieties of potatoes (English and American), amongst which we had already tried a dozen the previous year. These are those, then, which, in addition, were the most to be recommended, or have given the best results.

But there is one fact to notice—that is, amongst so many varieties, and in a year so unfavourable, not a single tuber was attacked by the malady. That is probably from the manure used; for there was not a particle of farmyard manure, and the field had not had any for four years; when all the cultivators who surround us, and who cultivate on a large scale for the markets of Paris and for exportation, have had many gaps amongst their varieties, which are commonly called Feuille d'Ortie, La Marjolin Tetard, La Segonzac (or St. John), the Long Yellow of Brie or Hollande, the Saussage, and the Chardon. It is true they manure excessively with the night soil of Paris.

Have not those varieties (introduced a long time ago), by reason of the want of care taken by the greater part of the cultivators in the choice of their seed for sowing, lost their vigour and the characters properly belonging to specimens originally introduced?

Amongst the greater part of the cultivators, the Segonzac and the Hollande have given very insignificant results. The return of the Saussage has been equally inferior with that of the preceding. As to the Chardon, it has grown imperfectly in many places, and it had to each plant a mass of little tubers, which were only fit to utilise for cattle.

It is, then, of the first necessity for agriculture to return to new varieties obtained from seed—always more vigorous, more productive, and more resistant to the malady. All the cultivators know by experience that the greater part of the grain sown from imported seed from another country gives the best results, and less subject to disease, than those which have existed a long time in our own cultivation.

It is the same with the potato; and, if we wish to constantly have good results, we must renew, from time to time, our seed, and have recourse to new varieties so remarkable, constantly to be obtained in America and England.

In the collection which we have cultivated, forty varieties were excellent. However, our choice has been much more restricted; and I doubt not that all the cultivators who try them will be satisfied with the quality and the return.

I divide them into three varieties:—

1. The early potatoes for first use.
2. The second earlies.
3. The late varieties.

1. *The Early Varieties.*

*Royal Ashleaf, Improved by Rivers.**—This variety, improved from the original English Ashleaf, is a potato of the first merit. Its tubers are better formed than in the ancient type; the stem is more thick-set and less elevated, which allows of its being employed with advantage for forcing in the place of the Quarantaine, over which it possesses the advantage for open-air cultivation of growing again when its first stems have been destroyed by the frost of spring, which does not take place with the other. It is, besides, as early, and the return is greater.

English Ashleaf, commonly known by the name of Feuille d'Ortie, or Nettle-leaf, in the culture in the environs of Paris, where it completely takes the place of the Quarantaine, over which it presents, as in the Ashleaf of Rivers, the advantage of growing again when its young shoots have been destroyed by the frost of spring.

These two varieties are of long standing, and much sought after; besides that, they do not break too much in the preparation of the cook.

Fox's Seedling, Improved (tubers improved by Fox).—The best of early round potatoes: its form is pretty; its eyes are little apparent; its quality without fault; it merits to be introduced into our cultivation, for the return is very large.

These three varieties may be cultivated with advantage in the little plots and the garden of the farm.

2. *Second Series* (*Second Early*).

Woodstock Kidney.—This superb variety, obtained from one of Mr. Fenn's seedlings, is, without contradiction, above criticism as to quality, form, and crop, amongst the second early potatoes; and it may replace the Segonzac and the Hollande with great advantage.

The shape, as its name indicates, is that of a kidney; its eyes are little apparent; its skin is grey and a little red; and its appearance is very flattering. It is an excellent novelty, which merits to be introduced into the large and small culture, where it is called upon to take the first rank amongst the second early varieties.

Its stem is short, and spreads out a little; its tubers form rapidly, and arrive at their full size before the stems commence to wither, which permits them to be taken up before they are ripe, for immediate sale. This variety was in commerce last year, and is very scarce.

Snowflake.—Excellent variety: form elliptic, a little flat; skin

* Mr. Rivers grew this potato, but disclaimed the honour of raising it. *Translator.*

white russet; flesh excellent—very floury; variety much sought after, and very productive. May be, like the first, taken up before complete maturity, to be directly sold.

Rector of Woodstock.—One of our best round potatoes; the flesh is yellow, and the skin white and smooth; the shape is round, a little flat, very handsome. It produces enormously.

3. *Late Series.*

Sutton's Magnum Bonum.—Magnificent and good. This variety found amongst a batch of seedlings by Mr. Martin Sutton, four or five years ago, is without contradiction the finest potato obtained during the past ten years; for it possesses, besides a good shape, a flesh of a superior quality, and gives a return which has not been surpassed by that of the Early Rose, which is a little left behind at the present time.

Its shape is elliptic, a little flattened at the extremity which is attached to the stem; the skin is white russet; the eyes are almost nothing, and little apparent; the flesh is white, extremely delicate, and very floury; it may be dug up and consumed before it is quite ripe, and preserves all its good qualities up to the month of May following, for it is very late in shooting.

The stems are strong, thick-set, and hold themselves upright; when its maturity advances they all turn yellow in eighteen days, and it is very difficult to find any shoots later than the others. This vigour and this regularity of growth have caused it to escape up to the present time the disease; for in France, where M. Duduoy has already grown it two years, and in England, where it is now cultivated on a very large scale, one has never seen a tuber attacked. All its tubers are found grouped round the stem in a very small space, and their volume is very regular; it is difficult to find amongst them three or four smaller than the generality, and if you do they are useful for planting.

In the trial ground of St. Ouen-l'Aumone all the stools had from twenty to twenty-five tubers, and the return was 30,000 kilos to the hectare.*

I need not longer occupy myself in trying this superb variety, which is equally good for cooking purposes, for starch making, or for cattle, and which can give such great profits for its price, thanks to its form, will always be higher than that of the Chardon; so I do not hesitate to recommend it to replace that potato entirely.

It comes to maturity at the end of September or commencement of October.

Sutton's Red Skin Flourball.—This excellent variety, dating some years back, is the most to be recommended amongst the round varie-

* 30,000 kilos to the hectare are about equal to 11 tons per acre.

ties, and, perhaps, the best for the starch manufactories; for all the starch manufacturers to whom we have presented it have requested us to propagate it as much as possible, convinced that the manufacturer and the cultivator will both find their advantage, which is generally so unusual.

Its form is round and a little flat; its eyes apparent; its skin a fine red vermilion; its flesh white and very farinaceous when it is boiled in water; its stems are strong and thick-set, rather more spread out than those of the Magnum Bonum, and it ripens evenly a little late.

It ought, with the last, when it gets well known, to be cultivated by everybody, for it produces very much, the return having been 30,000 kilos this year in the experimental field.

Turner's Schoolmaster.—Round potato, skin white, a little red, of a very fine shape, very farinaceous, and having given a return of 25,000 kilos to the hectare. Before obtaining Magnum Bonum and Flourball, this was the potato for large cultivation in England, but it is a little left behind now in comparison with these two last.

These nine varieties, chosen from the best, will suffice amply for our wants; but permit me to recommend, more particularly for those who cultivate for the Paris market, also the country markets, to keep to the three following varieties:—

Royal Ashleaf for first crop;
Woodstock Kidney for second;
Magnum Bonum for third.

For those who cultivate for the starch manufacturers, I particularly recommend the Red Skin Flourball, which is without contradiction the richest in starch.

For exportation to England and Belgium I specially recommend Magnum Bonum and Flourball; for then one would obtain, above all, quantity, and have the fewest varieties, and so facilitate the loading of a waggon or barge.

Another late variety is put in commerce this year, under the name of Reading Abbey, by the English firm of Sutton. This variety, like the Magnum Bonum, has perfectly resisted the disease in England and Ireland this year, which, however, has been so disastrous to the greater part of the other varieties; and, no doubt, this will turn out an excellent novelty when the price is sufficiently low.

Its form is rather oval than round, its flesh is white and very floury. The crop has been large this year in England, and this variety, exhibited at most of the shows in the autumn, created a sensation.

When we have cultivated this variety in the experimental ground we shall be able to speak with safety; and, after the results we have seen in England, I doubt not that this excellent novelty will take its place at the side of Magnum Bonum for cultivation on a large scale.

I will now add a word on the manure that we have employed, and which I think the most suitable for potatoes. I have not mentioned however, the mode of cultivation that we have been obliged to follow.

The ground was occupied by turnips, and was once ploughed in the month of January and left in that state, followed by a turn of the scarifier. At the commencement of April we buried the following manure:—

300 kilos of Nitrate of Potash.
700 kilos of Superphosphate.
200 kilos of Plaster of Paris.

In all 1,200 kilos to the hectare, representing an expense of 270 francs. The planting was towards the middle of April for all varieties.

This composition of manure is the most reasonable, according to my idea, for potatoes.

When we use a certain quantity of manure from the farm, one can make a half manuring with artificials, taking care to bury the dung before winter and to add to it only 600 kilos of artificial manure so high that one can bury it by a stroke of the scarifier at the time of planting, or some days before.

NOTE.—M. Birot goes too far in saying that Magnum Bonum was entirely free from disease; here there were a few bad. I think he does not give very good advice in recommending the growth of the Flourball for the English market; the price is very low in comparison with Snowflake and others.—*Translator.*

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